Shaping Tomorrow's Built Environment Today

MINUTES (DRAFT)
Environmental Health Committee (EHC)
June 24, 2024 - Annual Meeting

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

MEMBERS PRESENT:
Marwa Zaatari, Vice-Chair
Dimitris Charalambopoulos
Benjamin Jones
Howard Kipen
Linda Lee
Ken Mead
Corey Metzger
Connor Murray
Lisa Ng
Kathleen Owen
Ashish Rakheja, *Coordinating Officer*
Max Sherman
Donald Weekes

MEMBERS NOT PRESENT:
Bill Bahnfleth, Chair (due to illness)
Farhad Memarzadeh
Mark Ereth

ASHRAE STAFF:
Steve Hammerling, *MORTS*
Emily Porcari, MSLGA
Tara Thomas*, AA*
Alice Yates, *DGA*

GUESTS:
Katja Auer
Devon Abellon
Bob Bowcock
Costas Balaras
Charlene Bayer
Seema Bhangar, *Incoming Member*
Hoy Bohanon
Richard Bruns, *Incoming Member*
Brendon Burley
Nuria Casquero-Modrego
John Cirrito
Darryl Deangelis
Nolan Demos
John Flannery
Carl Grimes
Anuj Gupta
Mark Jackson
Georgia Lagoudas
John McKeon, *Incoming Member*
Bill McQuade
LanChi Nguyen Weekes
Thomas Parker
Paricheher Salimifard
Larry Schoen
David Shuler
Larry Smith
Stephanie Taylor
Pawel Wargocki
Jianshun Zhang

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MOTIONS

No.	Motion	STATUS
1	that the draft minutes from the June 10th meeting be approved	PASSED
2	that the ASHRAE Rules of the BOD be amended as shown:	PASSED
3	that the following information be added to the EHC Reference Manual:	PASSED
4	that EHC approve a 2024 Trends and Research Gaps report	PASSED

LIST OF ATTACHMENTS

No.	Attachment
A	Epidemic Task Force Final Report
B	2023-24 MBO Final Report
C	2024-25 Draft MBOs
D	PEAC presentation
E	2024 Trends and Research Gaps report
F	Long Term Plan for IEQ Conferences

LIST OF ACRONYMS

AIA	American Institute of Architects
AIHA	American Industrial Hygiene Association
BOD	Board of Directors
CEBD	Center for Excellence in Building Decarbonization
CEC	Conferences and Expositions
CO	Coordinating Officer
CO2	Carbon Dioxide
CTTC	Chapter Technology Transfer Committee
DRSC	Document Review Subcommittee
EH	Environmental Health
EHC	Environmental Health Committee
EIB	Emerging Issue Brief
ENDS	Electronic Nicotine Delivery Systems
ETF	Epidemic Task Force
ExO	Ex-Officio
GOE	Government Outreach Event
GAC	Government Affairs Committee

IAQ	Indoor Air Quality
IEQ	Indoor Environmental Quality
IEQ-GA	Indoor Environmental Quality Global Alliance
MBO	Management by Objectives
MOP	Manual of Procedures
MOU	Memorandum of Understanding
MTG	Multidisciplinary Task Group
PD	Position Document
PEAC	Presidential Elect Advisory Committee
ROB	Rules of the Board
SME	Subject Matter Expert
SGPC	Standing Guideline Project Committee
SSPC	Standing Standard Project Committee
TC	Technical Committee
TPS	Title, Purpose, Scope

ACTION ITEMS

INDIANAPOLIS ANNUAL 24 MEETING

No.	Responsibility	Action Item	Status
1	Staff	Distribute *Human Health and Wellness in the Built Environment* to EHC for review and comment	
2	Staff/EHC	Send *Combustion of Solid Fuels and Indoor Air Quality in Primarily Developing Countries* to EHC after to consider a motion to reaffirm at their next meeting	
3	Staff	Distribute the *Limiting Indoor Mold Growth and Dampness in Buildings Systems* PD for EHC members to recommend a decision at next meeting	
4	EHC	Review EIB format and consider proposals for new EIBs of interest to EHC and ASHRAE	
5	Staff	Update EHC Reference Manual to reflect approved changes to award judging procedures	
6	Education Subcommittee	Review point criteria for award eligibility to determine if it should be updated.	
7	EHC	Review and comment on Chapter F36, Climate Change, to harmonize with EHC chapter by July 15th	
8	Outreach & Coordination	Develop and propose a list of committees/organizations to liaise with	
9	EHC	Review and give feedback on 24-25 MBOs and subcommittee roster before next EHC meeting	

JUNE 10, 2024 MEETING

No.	Responsibility	Action Item	Status
1	Lee	Send list of programs for Indianapolis	Complete

CHICAGO WINTER 24 MEETING

No.	Responsibility	Action Item	Status
CH1	Metzger, Schoen, Jones	Lead the revision of the Electronic Nicotine Delivery Systems (ENDS) in Indoor Environments EIB	Ongoing
CH2	Jones	Get in contact with DTU team working *Indoor Passive Panel Technologies for Air Cleaning in Buildings* and make recommendation on EIB	Complete
CH3	Burley/Clark	Review template and consider drafting EIB on IEQ sensors and building automation systems	Ongoing
CH5	EHC	Offer ideas for environmental health report on gaps and emerging trends	Complete
CH6	Policy Subcommittee, Clements, Bohanon, Charalambopoulos	Develop proposal (TPS) and chair for an ASHRAE PD on Ozone/Indoor Chemistry	Ongoing
CH7	Education Subcommittee	Education Subcommittee asked to review current EH Award procedures and recommend changes	Complete

1. **Call to Order & Welcome**
   Vice-Chair Zaatari convened the meeting at 8:00 AM EDT.

   A. ASHRAE Value Statement – *In ASHRAE meetings, we will act with honesty, fairness, courtesy, competence, inclusiveness and respect for others, which exemplify our core values of excellence, commitment, integrity, collaboration, volunteerism and diversity, and shall avoid all real or perceived conflicts of interest. Our culture is one of inclusiveness, acknowledging the inherent value and dignity of each individual. We celebrate diverse and inclusive communities, understanding that doing so fuels better, more creative and more thoughtful ideas, solutions and strategies for the Society and the communities our Society serves. We respect and welcome all.*

   B. *Code of Ethics* – *Please review prior to meeting*

   C. *Core Values* - *Please review prior to meeting*

   D. *Diversity Statement* – *Please review prior to meeting*

2. **Approval of Minutes**
   - June 10, 2024 Meeting (posted to Teams)

     (1) it was moved (Sherman) and seconded (Lee) that the draft minutes from the June 10th meeting be approved

     BACKGROUND: draft minutes were posted to Teams for review on June 13th

     MOTION 1 VOTE: 12-0-0 PASSES

3. **Review of Agenda**
   The following were added to 10. Other Business:
   - Unified metric for IEQ (Bayer)
   - Report from Alice Yates on Government Affairs Committee (GAC)

4. **Remarks from Chair/VC**
   - **Motions from Past Meetings requiring higher approval**
     - No motions from June 10 meeting
     - The Epidemic Task Force (ETF) final report (**Attachment A**) approved by EHC was distributed and would be reported to Technology Council at this meeting.

   - **Review of Action Items**
     EHC reviewed the status of action items. A summary is included above with details reported in subcommittee agendas below.

   - **MBOs and MBO Assignments**
     A final report on EHC's 2023-2024 MBOs is included as **Attachment B**. Details would be discussed in Subcommittee meetings.

     A draft of EHC's 2024-2025 MBOs is included as **Attachment C**.

Both updates will be reported to Operations subcommittee of Technology Council.

5. **Remarks from BOD Ex-O and CO**
   The PEAC report was presented (**Attachment D**) to EHC. Highlights of interest to EHC include:
   - President Dennis Knight's theme for 2024-25 is *Empowering Our Workforce: Building a Sustainable Future*
   -
   - Feedback sought from EHC on ASHRAE Strategic Plan. See link for form at www.ashrae.org.
   - President-Elect Bill McQuade Presidential theme is related to healthy buildings.
   - New Center for Excellence in Building Decarbonization (CEBD) will include a liaison from EHC.
   - Nominations for elected committees due September 2024. Nominations for appointed committees due February 2025

6. **Policy (Metzger)**
   - Position Document Updates
     - *Human Health and Wellness in the Built Environment*
       PD committee is meeting this afternoon to consider a draft document for EHC to review and comment on.

       Staff was asked to distribute PD to EHC members for comment when available (**Action Item 1**).

     - *Filtration and Air Cleaning* (Wargocki)
       PD committee addressed review comments with revisions to the position document. This document is on the DRSC agenda to consider approval tomorrow. It can go to Tech Council and the Board of Directors to consider approval at the Annual Meeting.

     - *Indoor CO_2* (Persily or Bahnfleth)
       Wargocki reported that the PD committee has started meeting. They are considering new literature since the last version was published to help update PD recommendations and positions.

     - *Combustion of Solid Fuels and Indoor Air Quality in Primarily Developing Countries*
       A reformatted version of this PD is available for EHC to consider for reaffirmation. Staff would send to EHC after meeting for EHC to consider a motion to reaffirm at their next meeting (**Action Item 2**).

     - *Limiting Indoor Mold Growth and Dampness in Buildings Systems*
       This PD expires in November 2024. TC 1.12 is co-cognizant and is discussing a recommendation for revision, reaffirmation or withdrawal. EHC can consider a recommendation as well.

Staff would distribute the Mold PD for EHC members to recommend a decision at next meeting (**Action Item 3**).

- Unvented Combustion Devices and Indoor Air Quality
  A revision to this PD was approved at the Winter Meeting. The PD committee was appointed in the spring but meetings have not yet convened. Chair Paul Francisco will coordinate the start shortly.

- *Ozone/Indoor Chemistry* (new)
  Clements, Bohanon, Charalambopoulos were tasked to develop a PD proposal, title, purpose and scope (TPS) and chair for a new PD on the topic. Clements was identified as likely chair but a TPS has not been drafted. Can continue to monitor as warranted.

- Emerging Issue Briefs
  Approved and archived briefs posted to ASHRAE website (here).

  Metzger, Schoen and Jones noted they are working to revise the Electronic Nicotine Delivery Systems (ENDS) in Indoor Environments EIB. They've started an updated literature review.

  There are new topics identified as possible EIBs to develop:
  - *Indoor Passive Panel Technologies for Air Cleaning in Buildings* – Jones reported he has reached out to DTU for their feedback on the topic to determine if an EIB on topic is warranted.
  - *IEQ sensors and building automation systems* – Burley and Clark were not in attendance, but it was reported that there is a draft and have been some email communications
  - Bayer and Burley mentioned a possible EIB on *Outdoor Air Events,* related to long term impacts of wildfires, toxic clouds, etc.
  - Guest Bob Bowcock mentioned a possible need for an EIB on water chlorination treatments.

  Members were asked to review EIB format and consider proposals for new EIBs of interest to EHC and ASHRAE (**Action Item 4**).

b) **IEQ-GA Rules of the Board**
A motion was developed to institute and administer the IEQ-GA into the ASHRAE ROB was drafted. The draft motion was sent to Society Rules Committee for review. No feedback has been offered at this time.

(2) it was moved (Metzger) and seconded (Weekes) that the ASHRAE Rules of the BOD be amended as shown:

2.106.001.12 Indoor Environmental Quality Global Alliance (IEQ-GA)

2.106.001.12.1 Membership

a) ASHRAE is a founding Full Member of the Indoor Environmental Quality Global Alliance (IEQ-GA) a consortium of organizations incorporated in Belgium and shall pay annual dues to maintain its continuing membership.
b) Membership is subject to review every five years, to be completed in each calendar year ending in either 4 or 9.

2.106.001.12.2 Representation
a) ASHRAE shall appoint a representative and an alternate representative to IEQ-GA to serve terms of up to three years.
b) The representative and alternate representative shall be recommended by the Environmental Health Committee and confirmed by Presidential appointment when renewal of representatives is required.
c) c. ASHRAE shall fund travel costs for its representative to attend one in-person meeting of IEQ-GA per year.

2.106.001.12.3 Oversight
Responsibility for monitoring of IEQ-GA shall be assigned to Environmental Health Committee

BACKGROUND: At the ASHRAE Board of Directors meeting held on November 8th and 9th of 2018, two motions related to IEQ-GA were approved:

Motion 14: ASHRAE participate in the incorporation of the Indoor Environmental Quality – Global Alliance (IEQ-GA) and continue its membership, subject to review every five years.

Fiscal Impact: Up to $5000 per year, including 1) an estimated $2200 contribution to incorporation costs, 2) to be determined, but lower, annual membership fees in subsequent years, and travel cost for ASHRAE's representative to an annual in-person meeting.

Motion 15 as amended: that responsibility for monitoring and reporting on IEQ-GA be assigned to Environmental Health Committee (EHC) and that EHC recommend candidates to serve as the ASHRAE representative and alternate for terms of up to three years. The IEQ-GA candidates recommended by EHC must be confirmed by Presidential appointment.

The intent of the proposed changes are to include these Board actions in the rules.

FISCAL IMPACT: As noted in background.

MOTION 2 VOTE: 12-0-0 PASSES

7. Education (Lee)
Lee thanked subcommittee members for their work and for attending monthly meetings through the year.

- EHC programs for Indianapolis
  A list of environmental health related programs in Indianapolis was emailed before the

meeting. All members are encouraged to attend.

- EHC program ideas for Orlando
  The deadline for Winter Meeting program submissions is August 2nd.

- Discuss Triennial IEQ Conference with CEC – MOP Changes
  CEC developed a document that is not ready for EHC approval. EHC comments will be sent back to CEC to develop a formal document on EHC's role in organizing the ASHRAE IEQ Conference.

- Public CTTC webinars (two for 2023-24)
  There have been some general ideas but limited activity on this topic. Education subcommittee will keep this on their list for next year.

- EH Award procedure changes
  A draft motion was prepared ahead of the meeting. EHC reviewed and made changes as shown.

  (3) it was moved (Lee) and seconded (Owen) that the following information be added to the EHC Reference Manual:

  Process
  1. Nominations are submitted to ASHRAE staff
  2. ASHRAE staff confirms that the nominees meet the award qualifications
  3. Qualified candidates are submitted to the Education subcommittee
  4. Educational subcommittee vote to select the top two candidates
     a. The ~~full~~ subcommittee assigns a mark 0 to 5 for ~~the~~ each ~~two~~ candidates.
     ~~b. The person with the highest mark wins.~~
     c. The two candidates with the highest scores will be sent to full committee.
     d. In case of a tie, the candidate with the most Bahnfleth Award points wins.
  5. Education subcommittee forward the names of the two candidates to the Chair of EHC
  6. The Chair of EHC shares the names of the two candidates with the full committee.
     a. The full committee votes on a winner
     b. In case of a tie, the candidate with the most Bahnfleth Award points wins

  BACKGROUND: The Donald Bahnfleth Environmental Health Award is an annual recognition conferred by EHC to honor outstanding volunteer service dedicated to environmental health issues. Currently, there is no established procedure outlining how EHC assesses multiple nominees. The Education Subcommittee has developed a formal evaluation process for nominees, which includes guidelines for addressing tie situations. This information would be included in section 4.Judging.

  MOTION 3 VOTE: 10-0-0 PASSES

  Staff would update EHC Reference Manual to reflect these changes (**Action Item 5**).

  Weekes asked if the point criteria to determine eligibility was appropriate of if it was too restrictive. Education subcommittee agreed to review point criteria (**Action Item 6**).

- IEQ Column Updates (Burley)
  Burley thanked authors for having article every month in last Society Year. He is seeking a submission for 2 weeks if possible with a July 8 deadline. McKeon noted he may have a topic ready.

  Burley asked for Asked for new ideas for future columns as well. Ideas include:
  - More articles on Standard 241. Suggested sub-team from 241 that has not yet published column article can write next article.
  - Awaiting article on ETF final report
  - potential column on EH gaps document (Kipen)
  - columns from AIHA/ASHRAE MOU
  - columns from AIA/ASHRAE agreement
  - CIBSE mentioned as well for joint articles

- Handbook chapter status
  Lee thanked Ng and her team for developing chapter F10 edits. Thanks as well to those who reviewed and approved.

  Scott Sherwood, Chapter F36 on Climate Change, suggested we harmonize the two chapters, specifically the IEQ impacts in Climate Change section. Ng will send to EHC requesting comments by of July (**Action Item 7**).

8. Outreach & Coordination (Weekes)
Weekes thanked members of subcommittee for work this year.

- IEQ2025 Conference update
  IEQ 2025, *Rising to New Challenges: Connecting IEQ with Sustainable Buildings,* will take place in Montreal on Sept. 24-26, 2025. Weekes noted the planning committee is meeting tomorrow. A call for papers has been issued. Weekes invited all to present or attend the conference. The committee will eventually need paper reviewers as well. See www.ashrae.org/ieq2025 for details.

  Bill McQuade noted this conference aligns well with his Presidential Theme for 2025-2026 on healthy buildings. They are exploring an add on to conference ahead or behind on a specific application or theme. He will be asking for EHC input/participation on efforts related to his theme.

- Discussion on ASHRAE IAQ Standards – Marwa Zaatari
  ASHRAE Standard 241 introduces a number of significant changes to how IAQ standards are designed (e.g., the use of equivalent clean air as the basis). The board envisioned other ASHRAE IAQ standards (170, 62.1, 62.2, etc.) incorporating 241. EHC Education Subcommittee would work to disseminate Standard 241 technical content. MBO will continue as 24-25 MBO.

- Annual EHS Trends and Research Gaps report
  (4) it was moved by the subcommittee that EHC approve a 2024 Trends and Research Gaps report **(Attachment E).**

BACKGROUND: As part of EHC's responsibility (ROB 2.406.001) to identify major environmental health trends impacting the practice of HVAC&R and inform the ASHRAE leadership and membership of these trends and their potential impacts,

MOTION 4 VOTE: 10-0-0 PASSES

There was discussion of adding new items and some edits that were not included in the 2024 report but can be included in a future report.

- Long Term Plan for IEQ Conferences
  ROB 2.406.003.1 requires EHC to maintain a long-range plan for Indoor Air Quality conferences and submit this plan to Technology Council at the Annual Meeting. EHC discussed a draft plan (**Attachment F**) and would include in report to Technology Council.

  [NOTE: Bahnfleth drafted a motion to amend *Motion to amend ROB 2.406.003.1. it was not discussed by EHC but can be considered at future meeting:*

  Motion: That ROB 2.406.003.1 be amended as follows:
  2.406.003.1 General Requirements This committee shall maintain a long-range plan for Indoor ~~Air~~ Environmental Quality conferences and submit this plan to Technology Council at the Annual Meeting.

  Background: Since 2016, EHC has broadened the scope of the IAQ conference series initiated in 1986 to address all components of indoor environmental quality to better conform to the scope of the committee.

- Liaison Updates
  No specific liaison updates were given. EHC may wish to consider a list of organizations or committees EHC wants to liaise with and identify specific liaison. The subcommittee was asked to develop and propose a list of committees/organizations to liaise with (**Action Item 8**).

9. Remarks by Incoming Chair

Zaatari thanked outgoing chair, Bill Bahnfleth for his work and leadership over the last society year. Bill will remain a voting member of EHC for a three-year term.

Zaatari also thanked outgoing members Farhad Memarzadeh and Mark Ereth for their participation on EHC.

Incoming members Richard Bruns (JHU Center for Health Security), Seema Bhangar (USGBC) and John McKeon (Allergy Standards Ltd) were welcomed to EHC. The subcommittee structure for 2024-25 would stay the same. Proposed subcommittee rosters are posted to Teams. Note, each now includes a chair and vice chair.

10. Other Business

Unified metric for IEQ (Bayer)
Bayer noted she was developing a proposal for a new Multidisciplinary Task Group (MTG)

on development of an IEQ metric(s). They would ask EHC to participate. SGPC 10 is developing an addendum with a definition of health as well.

However, Sherman noted EHC is developing an operational definition of acceptable indoor environmental health as an MBO and should be an EHC task.

Report from Alice Yates on GAC activities

Yates addressed EHC and thanked them for their work this year. One of GAC's aim is to get technical information for government representatives with a focus on elevating IEQ in regulations. Yates encouraged EHC members to consider applying for the SMEs for GOEs program (here) to communicate technical information effectively to government officials and policymakers.

SSPC 241

Sherman noted he was Chairing SSPC 241 meeting later today and would seek agreement that EHC Education Committee will set do outreach of 241 developed content. If there is agreement, details can be developed.

Event with Jerome Adams

McKeon invited EHC members to event he is hosting with ex US Surgeon General, Dr. Jerome Adams, now a professor at Purdue. Tonight 6-9pm at Hyatt (see details here). All were invited to attend.

11. Next Meeting

EHC will plan to meet virtually before next Winter meeting in Orlando. Subcommittees will be asked to meet intermittently as well.

Zaatari asked all to review 24-25 MBOs and subcommittee roster before next EHC meeting (**Action Item 9**).

12. Adjournment

Zaatari thanked everyone for their attendance and participation and adjourned the meeting at approximately 11:30 AM EDT.

ASHRAE Epidemic Task Force Final Report

Submitted: *March 11, 2024*

Prepared by: ASHRAE Environmental Health Committee (EHC) & ASHRAE Epidemic Task Force (ETF)

Executive Summary

During the period from March 2020 through June 2022, ASHRAE Epidemic Task Force (ETF) successfully created over 30 guidance documents and provided thousands of hours of training, interviews, and authored many articles to help disseminate the information created by the ETF. This report reviews the history of the ETF and presents its recommendations for continued development of technical information and research by ASHRAE's Working Groups (WGs) to inform guidance to mitigate the transport of infectious aerosols in the built environment.

The ETF identified eight (8) key areas that should be the focus of current and future work by ASHRAE's WGs, in collaboration with other organizations as necessary. They are as follows:

1. Determination of Equivalent Clean Air (ECA) delivery rates (previously called out as equivalent clean air in ETF documents but ECA in Std 241) required during occupancy for reduced risk during airborne infection emergencies, including requirements for healthcare and residential spaces. ECA includes outdoor air, and then cleaned or inactivated recirculation air from filters and air cleaning devices.
2. Development of the metrics and test procedures needed to evaluate all air cleaner types (those installed in central HVAC systems as well as in-room devices). These are needed to fill knowledge gaps that affect standards development and to educate the public about air cleaning options and the quantity of EOA produced by air cleaners .
3. Specific guidance on the impact of room air distribution on infectious aerosol exposure risk that includes the effects of space layout, furniture, occupant locations, and potential air cleaning devices (e.g. in room air filter units, ceiling fans) and air distribution method (underfloor air delivery (UFAD) versus Overhead versus Sidewall Displacement).
4. Guidance for natural ventilation to reduce exposure to infectious aerosols
5. Energy impact to the facility of incorporating the recommended engineering controls to achieve ECA targets.
6. Development of methods to validate the implemented engineering controls that include the measurement of actual microbial (or equivalent tracer) concentration reduction..
7. Further investigate and provide guidance on humidification as an engineering control. This includes practical methods for assessing the limits of relative humidity (RH) that can be safely maintained in a building or part of a building. This technical guidance should also better document, and communicate, the impact of relative humidity on airborne infectious disease transmission for a range of airborne pathogens..

ASHRAE is already addressing some of these issues, for example, through the publication of a new standard for control of infectious aerosols (Standard 241-2023) and recommendations for improving school indoor air quality that include measures to reduce risk of airborne disease transmission.

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Background

The ASHRAE Epidemic Task Force (ETF) was established on March 12, 2020 as a result of consultation between the ASHRAE Executive Committee and the Environmental Health Committee (EHC), which served as its oversight body. The first meeting of the full ETF was a virtual meeting on March 29, 2020 and its 31st, and last, meeting was an in-person meeting on June 27, 2022 during the 2022 ASHRAE annual meeting, after which it disbanded, having substantially completed its mission. The final task of the ETF is to make recommendations for future action by ASHRAE. That task was assigned to an ad hoc subcommittee within the Environmental Health Committee (EHC), which developed this report.

The overarching goal of the ETF was to coordinate deployment of ASHRAE's technical resources to provide guidance on use of heating, ventilation, and air-conditioning systems during the Covid-19 pandemic and prepare for future epidemics. The ETF produced extensive guidance that is archived on the ASHRAE web site (ashrae.org/covid19) and collaborated other organizations in developing joint guidance. A The primary role of the task force was to maintain communication with members, industry partners, building owners, facility operators, government agencies and the general public. .

Specific responsibilities of the task force included:

- Serving as a clearinghouse to review all technical questions and requests for technical guidance submitted to ASHRAE
- Coordinating activities of ASHRAE's internal resources
- Partnering with and monitoring the activities of external organizations, including the more than 60 members of the ASHRAE Associate Society Alliance (AASA) of organizations related to the HVAC&R industry around the world
- Reviewing, organizing, consolidating and publishing clear and concise summaries with citations of the most relevant information available to the built environment

The ETF was authorized by Presidents Boyce, Gulledge and Schwedler to work with oversight from the ASHRAE Environmental Health Committee (EHC). The ETF was formed with the knowledge that it would complete its charge and disband and that the information it created would be archived and disseminated to the working groups within ASHRAE to incorporate, as those WGs deemed appropriate, into their documents. As part of the sun setting process the ETF and its specialty work groups wrote transition plans so that the work products and lessons learned during the COVID-19 pandemic may be integrated into the work of existing standards and Working Groups (WGs) within ASHRAE.

The ETF was sunset at the end of the 2021-2022 Society year and. the functions of the ETF shifted tothe EHC. EHC will continue to support other groups within and outside ASHRAE as requested to help use the guidance created by the ETF and have it incorporated into working group documents.

Recommendations

With the preparation of Transition Reports by each teams and input from the ETF as a whole, the ETF's final task is complete. The intent of this transition report is that the extensive and valuable body of work generated by the ETF be shared so that it will have continuing impact.. The groundwork laid by ETF has already proved extraordinarily valuable in the development of ASHRAE Standard 241-2023, which was completed by a team that included many former members of ETF.

The somewhat voluminous and, in some cases overlapping, recommendations from the ETF teams were analyzed and combined into eight overall recommendations deemed to be most critical for ASHRAE to adopt. Each item has additional detail versus the description used in the executive summary.

Item 1 - Equivalent Outdoor Air Requirements for Infection Control

Equivalent Outdoor Air (EOA) quantities required during occupancy for reduced risk during airborne infectious disease outbreaks are needed, including values for healthcare and residential spaces as COVID-19 becomes endemic and to protect against other significant airborne pathogens such as influenza, measles, and tuberculosis. EOA includes outdoor air, and then cleaned or inactivated recirculation air from filters and air cleaning devices. [Note that the "Equivalent Outdoor Air" concept utilized in ETF guidance is adopted in ASHRAE Standard 241-2023 as "Equivalent Clean Air."]

The ETF did not publish targets for equivalent clean air quantity to be delivered to the breathing zone of occupants in typical indoor environments to reduce the airborne transmission risk of SARS-CoV-2 to an acceptable level. The ETF science team worked on an approach based on reaching an 'acceptable' level of individual risk (i.e., <1%) assuming at least one susceptible individual is present and keeping the reproduction number (Rt), which shows the population risk

of COVID-19 transmission, below 1 for the duration of an outbreak.The ETF science team suggest a minimum target of 0.75 cfm/ft2 to be added to ASHRAE Standard 62.1 and 62.2 minimum ventilation rates. The suggested approach was not approved as it was deemed not applicable to many space types. The ETF limited its recommendations to compliance with ASHRAE 62.1 or 62.2 ventilation rates and use of MERV 13 filters for recirculated air and considering the use of additional measures to increase protection. This was done in part because of widespread acceptance of recommendations from sources including the US CDC and Harvard School of Public Health. .

The ETF published requirements for minimum post-occupancy flush-out time that corresponds to a calculated clearance of 95% of the virus or, prescriptively, two hours. For each space, the user could back calculate the equivalent clean air based on the core recommendations and the time required for flush-out using ASHRAE ETF published Equivalent Outdoor Calculator.

Research needs to be done to define an acceptable level of risk during infection mode similar to the “acceptable level of indoor air quality” defined in ASHRAE Standard 62.1, 62.2. ASHRAE needs to lead the development of a pathogen mitigation standard that defines minimum quantities of equivalent clean air for different space types including residential, healthcare, and commercial spaces and for different disease severity.. ASHRAE Standard 170 should investigate a change to the ACH metric to CFM and possibly tie it to CFM/person. ASHRAE needs to develop user guidance and calculators to make it easy for the user to adopt such a Standard. [Note: ASHRAE Standard 241-2023 does respond to this recommendation, but it is a new standard with much room for further development.]

Item 2 - Air Cleaning

The ETF recommended use of air cleaning to reduce the viral load in the air. Since HVAC media filters and germicidal UV are the best understood of the air cleaning options, these were the options that were highlighted in the ETF guidance. Information on other technologies was requested frequently, but there was little reliable information to share. The pandemic increased the awareness of the benefits of air cleaning, but it also brought many of knowledge gaps related to their use into the light. Given the importance of air cleaning in schemes to improve indoor air quality sustainability, it is essential that the state of knowledge be improved in the future.

The ETF recommends that ASHRAE work with the air cleaning community - manufacturers, specifiers, users, and researchers to determine the metrics needed to evaluate all air cleaners for effectiveness and safety in a way that is useful for predicting performance in application.

> Removing pathogens from the air or inactivating them is an important complement to removal by dilution with outdoor air or local exhaust. Ventilation with outdoor air is highly energy intensive both in absolute terms and in comparison to air cleaning technologies..

Some air cleaning technologies are well understood while little conclusive evidence exists for others. Depending upon the air cleaner type, knowledge gaps include performance prediction, risk from direct emissions, and secondary chemistry. Not enough is known about the aged performance of most air cleaners, even fibrous filters.

The ETF recommends that ASHRAE work with the air cleaning community to determine the test protocols and metrics needed to evaluate all air cleaners so that professionals and the public are well-informed about air cleaning options. Metrics are needed to address both the effectiveness and safety of reactive air cleaners (RAC) and UV (especially for emerging wavelengths other than the conventional 254 nm UVC produced by mercury vapor lamps) and how to compare their use to other controls. Suggestions on these issues come from most of the committees and generally overlap or support each other.

Better understanding of how all air cleaner performance changes with operating conditions (e.g., temperature, humidity, air contaminant profile) and over time is needed to ensure both that performance is maintained throughout air cleaner life and that aged equipment does not become a source of hazardous emissions. Much discussion about fibrous filters by the ETF centered on whether MERV ratings determined in accordance with ASHRAE Standard 52.2 were sufficient or whether the optional MERV-A ratings (Standard 52.2, Informative Appendix J method) should be required. The MERV-A rating conditions filters with KCl particles prior to testing with the intent of obtaining a better estimate of end of life performance for electrostatically charged filters. [Note: ASHRAE Standard 241-2023 requires the use of MERV-A filters to receive prescriptive credit for filter clean air delivery.] Both the ETF Filtration and Disinfection and Commercial Buildings teams recommended adoption of MERV-A ratings in the future.. The Commercial Buildings team recommends that guidance on expected efficiency loss as a function of operating time be developed through research and made available through guidance documents. Changes in performance of other technologies with use need to be investigated. These effects include UV source and photocatalyst lifetimes, ionizer pin lifetime, dirt buildup on surfaces in the air cleaner, among others.

For technologies not currently addressed by existing, ASHRAE should support and encourage development of efficacy and safety standard tests and application standards for all air cleaners. Much work in this area was fostered during the pandemic, but on-going support is critical to both promulgation and implementation of these standards including Standard 241. [Note: ASHRAE Standard 241-2023 references existing standards where possible but many must be tested according to procedures in its Normative Appendix A. Significant issues with what are considered standard test methods are being uncovered through early efforts to apply the standard. Safety testing in Standard 241-2023 considers ozone, formaldehyde, and particles. The Indoor Air Quality Procedure of ASHRAE Standard 62.1-2022 provides additional guidance on indoor contaminant levels that may be relevant to the use of air cleaners, but there

remains significant uncertainty about which contaminants should be of the most concern and the focus of control efforts.]

The relative merits of using in-room air cleaners (IRAC) vs HVAC air cleaners and, specifically, how to include both easily in simple models of IAQ are needed. The Filtration and Disinfection recommends that ASHRAE investigate how to establish equivalence between IRAC and MERV 13 HVAC filters. They also ask for guidance on the official ASHRAE position on the popular DIY versions of IRAC. Healthcare and Residential teams recommend research on in-situ efficacy of filter-based IRAC including placement within the space while Residential recommends that ASHRAE emphasize their use as the best option for rapid response and that the Residential team should collect and publish a best practices guide. [Note: In the development of ASHRAE Standard 241-2023, knowledge gaps greatly limited the ability to establish minimum requirements for IRAC use. This remains an important are requiring further research and is closely related to room air distribution needs.

For germicidal ultraviolet systems, guidance on ASHRAE's support for Direct Irradiation Below Exposure Limits (DIBEL) was identified as a key area requiring further research. This is due in part to the interest in direct irradiation using 222 nm "far UVC light, but is also applicable to other wavelengths..

Item 3 - Room Air Distribution

Specific guidance on the impact of room air distribution on infectious aerosol removal is needed that accounts the space dimensions, furniture, occupant locations, impact of air cleaning devices , in-room fans, and air distribution method and layout (e.g., overhead mixing vs. stratified and personal ventilation).

It is well known that air flow patterns in spaces strongly affect contaminant distributions and contaminant removal effectiveness. However, to prospectively estimate such effects with accuracy is not practical given the current state of knowledge. The layout of aspace and its air distribution system including locations of air diffusers, air cleaners, ceiling fans , furniture, equipment, and locations of occupants can cause substantial differences in the concentrations of infectious aerosols throughout the space. Building Readiness, Healthcare Facilities, and Industrial Facilities teams recommend that ASHRAE develop better guidance on layout and communicate this information to the community. We will also need to model more layouts to be able to include a useful selection in the guidance. Industrial adds that the influence of ceiling/mixing fans needs to be better understood and communicated.

The ETF Commercial team recommends that research be done to investigate how Underfloor Air Distribution (UFAD) and Displacement Ventilation, using thermal plumes,

interact with infectious droplets including the risk of resuspensionof material especially for higher air change systems. This work should include measurements in actual settings and investigate the influence of air cleaner efficiency (e.g., MERV 13) in different airflow patterns. It should also investigate the influence of the airflow on direct transmission of infectious aerosols.

Item 4 - Natural Ventilation

Guidance for natural ventilation to ensure an acceptable supply of outdoor air for infection control is needed.

Contrary to what many might believe,far more buildings worldwide are naturally ventilated than mechanically ventilated to meet their needs for outdoor air. Even in developed countries, it is common for residential buildings to be ventilated only by infiltration and opening of windows. In developing economies, many commercial, retail, and institutional buildings are also naturally ventilated. Naturally ventilated buildings have fewer straightforward alternatives for increased equivalent clean airflow. Furthermore, the cost of feasible options such as adding in room air cleaners may be cost prohibitive for the majority of these facilities. Since ASHRAE is a global organization wh0se mission is to serve all of humanity, it should lead the development of guidance on effective use of natural ventilation to control infection risk in all applicable climate zones..

It is recommended thatResidential Buildings Committee initiate a research project to conduct a literature search to help the RBC and ASHRAE determine the probable extent of reliable risk reduction that can be achieved by opening windows or through other natural ventilation openings in both high-rise and low-rise residential and non-residential buildings.[Note: As was the case with other knowledge gaps identified by the ETF, the limited practical guidance on natural ventilation had a negative impact on what could be included in ASHRAE Standard 241-2023. Natural ventilation is a high priority on the SSPC 241 work plan for air distribution.]

Item 5 - Risk Assessment

Infection risk assessment for spaces and systems is needed to determine level of engineering controls required. The result of this risk assessment should provide levels of safety and ventilation, filtration, or air cleaning required. ASHRAE will likely need to team with outside organizations to better understand the generation and infectious rates for aerosols.

The ASHRAE ETF did not perform an infection risk assessment to determine equivalent outdoor airflow requirements beyond what is described in the “Equivalent outdoor ventilation” section. As noted, the approach that was tested at the time did not produce results that the task force felt confident recommending to the public. . None of ASHRAE’s indoor air quality standards are based on quantitative risk assessment from contaminant exposures, and Standards 62.1 and 62.2 do not address infection control at all. Standard 170 for health care facility ventilation gives requirements for some space types for which asepsis is an objective, but not on the basis of quantified risk. To accurately estimate the risk of infection from airborne exposure to infectious aerosols is a daunting, some would say impossible, task given the current state of knowledge. ASHRAE needs to encourage and support research to improve modeling of risk that can be used to establish requirements in standards and regulations considering the most significant inputs. ASHRAE needs to investigate how infection risk assessment can be incorporated into existing and new standards.. Because much of the expertise needed to analyze infection risk lies outside of ASHRAE’s technical and scientific sphere, it will need to team with outside organizations to better understand the generation, transmission and infection dose response for respiratory aerosols.

Item 6 - Energy Impacts

Energy impact to the facility when incorporating the recommended engineering controls to achieve the desired infectious risk reduction targets should be minimized.

From the beginning of the Covid-19 pandemic in early 2020, energy use impacts of increased engineering controls for infection risk was an issue. The earliest guidance published by ASHRAE generally, in the form of the 2020 revision of the ASHRAE Position Document on Infectious Aerosols and initial guidance from the ETF and others focused almost entirely on risk mitigation. However, it was immediately met with expressions of concern about impacts on energy use and operating cost. Subsequently, ETF guidance underwent major modifications in part to address these concerns. The results of these modifications are summarized in the ETF Core Recommendations document. Overall, the recommendation of the ETF is that, in considering how to prepare for future airborne disease outbreaks, energy use impact should be a key factor for discriminating among options with comparable risk mitigation ability. [Note-This can now be done in the context of complying with ASHRAE Standard 241.]

Two examples of how guidance changed based partly on energy considerations are outdoor air requirements and flushing of spaces between occupancy periods. In early guidance from most sources, it was recommended that outdoor air flow be increased as much as possible. This would result in large energy penalties and also could make it

impossible to maintain intended indoor temperature and humidity conditions. In the Core Recommendations the only recommendation for outdoor air was that it meet the minimum flow rate required by the applicable code or standard. This created opportunities for lower energy air cleaning solutions and strategies like reducing occupancy levels to be implemented. The purpose of flushing was to ensure that there was low risk of transmission to a new group occupying a space after it had been vacated by another group.This concept was extended initially to pre-opening and post-closing flushes. Considering the time between the end of one day's occupancy and the beginning of the next day, it was concluded that normal system operation and natural losses would clear the air without any additional intervention, so this requirement was dropped. In addition, a two-hour flushing period originally recommended was shortened to the time required for three changes of clean air.

A number of more specific issues for further study were proposed by ETF teams.

- The Industrial Facilities team recommends the development of a calculation tool to assist in making decisions about fiscal impact and economic feasibility. For situations in which outdoor air flow is increased, they felt that guidance should be available on the use of direct gas fired makeup air units, low intensity gas fired infrared radiant and evaporative cooling in.

- Building Readiness team, with the concurrence of both the Schools and Commercial teams, noted the importance of educating the public that they primary function of HVAC systems is to provide for the health, safety, and welfare (HSW) of building occupants while being as efficient as possible while satisfying the basic HSW requirements. The Building Readiness Team hoped that ASHRAE WGs could develop training on the impact of meeting HSW needs on energy.

Item 7 - Validation of Engineering Controls

Validation of implemented engineering controls that include the measurement of actual infectious aerosol (or equivalent tracer) in comparison to design intent..

Guidance provided by the ETF Core Recommendations and by the various ETF Teams was appropriate based on the best available information at the time their guidance documents were developed. That said, testing to determine the impact of recommended strategies (individually and combined) on viable SARS-CoV-2 or suitable surrogates could help to verify the efficacy of these strategies and could also help to prioritize

implemented strategies for different operating conditions. Additionally, as measurement of virions in a given space is not currently commercially available, the use of proxies to estimate the risk of infection within a given space should be further investigated. In general, there is a great need for improved testing procedures of all kinds - laboratory testing of equipment, validation testing in the field, and also continuous monitoring systems. This is a fertile area for future study and development of technology and guidance.

The Healthcare and Commercial Buildings Teams recommends conducting research related to validation of performance of individual engineering control strategies, including HVAC system filtration, the use of in-room air cleaners, increasing ventilation, air distribution/mixing, and others. The Commercial team also recommends sponsoring research related to the use of carbon dioxide and PM2.5 particulate matter as proxies for infection risk in a given space. Based on this research, further guidance can be created to prioritize implemented mitigation strategies and to consider how these strategies might be controlled based on actual observed space conditions.

Item 8 - Relative Humidity: Impact and Attainable Levels in Existing Buildings

Provide engineering insight and direction to determine the actual relative humidity (RH) levels that a facility can achieve, based on the envelope construction, that designers and operators should target, in order to potentially reduce the transmission of airborne infectious disease. This technical guidance should also document, and communicate, the impact of relative humidity on airborne infectious disease transmission.

For decades, the ASHRAE Handbook (specifically, the chapter on humidifiers in the Systems and Equipment Volume) has recommended both upper (60%) and lower (30%) limits for RH based on multiple criteria, including risk of disease transmission. Some have suggested that a lower limit of 40% is optimal from the perspective of reducing infection rates. Building science, technology, and standards have tended to focus on avoiding high humidity levels in buildings that can contribute to mold growth. It is not uncommon to have no humidification in even buildings in climates with cold, low humidity winter conditions that result in very low indoor RH during the colder months.

Humidification to the recommended levels for many buildings would result in condensation on windows and within the building enclosure, leading to multiple costly problems. Consequently, the beginning of the Covid-19 pandemic sparked a lively debate about whether buildings should - or could - be humidified as a measure to reduce risk of transmission. Because of concerns about feasibility and safety of significantly increasing humidity in many buildings, and the perceived relative importance of value of

humidification compared to other engineering controls (ventilation, filtration, UV, and others), the ETF's guidance recommended only maintaining design setpoints for humidity (and also for temperature). A further source of uncertainty contributing to the ETF's moderate stance on humidification is the fact that 1) most studies on the effects of humidity were conducted with microorganisms other than SARS-CoV-2 and 2) published studies indicate that microbial response to humidity varies significantly. Some microorganisms do, indeed, show a lower survival rate/lower risk of transmission in the 40-60% RH range, but some do not and trends of survival with RH vary.

Many resources are available related to control of moisture in building envelopes, but few that quantify the potential risks and benefits of humidifying buildings in cold climates during the heating season in an effort to prevent transmission of airborne pathogens. The existence of this knowledge gap led ASHRAE to sponsor 1630-RP *Update the Scientific Evidence for Specifying Lower Limit Relative Humidity Levels for Comfort, Health, and IEQ in Occupied Spades*, a literature review that was published in 2016. 1630-RP noted the limited and unconclusive nature of data published up to that time for viruses specifically and respiratory infections more generally. However, several more recent studies suggest potential significance of humidity at low levels that are cited in the current (2020 as of this writing) version. It seems clear that more research on the outcomes of indoor humidity levels is needed to support standards and guidance.

Development of guidance to help owners, architects, engineers, and operators understand when it is appropriate to provide humidification, what level(s) of humidity should be targeted, and whether other strategies may provide similar levels of mitigation is recommended by the Healthcare and Schools Teams. This guidance should consider the potential for damage to building structural components due to condensation created due to humidification.

Accomplishments of the ETF

The Epidemic Task Force has produced over 30 documents and guidance as well as thousands of articles, interviews, and presentations..

The following is a high-level timeline with links to key events and activities performed by the ETF since February 2020, that include :

- 196 media interviews (through June 22)
- 697 news articles on ETF content
- 11,020,488,046+ media impressions (total eyeballs that have seen ETF content)
- 108,642 total lifetime downloads of ETF content from website
- 713,009 webpage views
- 1,230 Technical inquiries from the public that were answered by the ETF

May 5, 2022 |ASHRAE Supported Follow Up Report on IAQ In Schools Released
April 29, 2021 | ASHRAE Supports USGBC IAQ Schools Survey and Report
April 5, 2021 | ASHRAE Epidemic Task Force Releases Updated Airborne Transmission Guidance
March 8, 2021 | New ASHRAE Course Offered on Reopening Universities and Managing HVAC Systems
February 4, 2021 | ASHRAE Provides Testimony at Congressional Hearing on COVID-19 Safety
February 2, 2021 | ASHRAE Epidemic Task Force Releases Updated Building Readiness Guide
January 14, 2021 | ASHRAE Epidemic Task Force Releases Core Recommendations for Reducing Airborne Infectious Aerosol Exposure and Communities of Faith Building Guidance
November 20, 2020 | New Alternative Care Site Guidebook Available to Help Respond to the Rising Need for Hospital Beds due to COVID-19
August 20, 2020 | Making Polling Places Safer
August 18, 2020 | ASHRAE Epidemic Task Force Releases Updated Building Readiness Guide
July 22, 2020 | ASHRAE Introduces Updated Reopening Guide Schools and Universities
May 7, 2020 | ASHRAE Offers COVID-19 Building Readiness/Reopening Guidance
April 20, 2020 | ASHRAE Issues Statements on Relationship Between COVID-19 and HVAC in Buildings
April 20, 2020 | En Espanol
March 31, 2020 | ASHRAE Epidemic Task Force Established
February 27, 2020 | ASHRAE Resources Available to Address COVID-19 Concerns

Team Report - General Information

These reports covered 3 specific areas, with some additional sub-areas. They are as follows:

1. Lessons Learned
    a. Reference Documents
    b. Open Issues
    c. Information for other ASHRAE Groups
    d. Issues Beyond this Guidance
2. List of Team-Generated Guidance
3. Technical References

There are ten (10) team reports that are located in **Appendix B.**

The teams that did not generate a final transition report are as follows:

- Communications Team. Since they were reporting on the impact and impressions of the ETF there was no technical information to pass to ASHRAE's Working Groups.
- Science Background Team
- Resource Inventory Team
- Applications (Please note that are addressed in Standard 241-2023)
- Developing Economies

Working Group Actions since ETF Disbanded

There have been many items that are already underway since the dissolution of the ETF. The following is a sample of those items:

1. SPC 241 published a new standard titled “Control of Infectious Aerosols”. A major driver for the development of the standard was a request from the White House COVID-19 Response Team in November 2022. The purpose of the standard is “to establish minimum requirements for control of infectious aerosols to reduce risk of disease transmission” that includes new and existing buildings. The standard was completed in less than six months following the White House request and approved for publication in June 2023 as ASHRAE Standard 241-2023. SPC 241P has been transitioned to a standing committee, SSPC 241, and the standard is on continuous maintenance.
2. Formation of Task Group TG-2.RAST (Reactive Air and Surface Treatment) that is concerned with advancing the knowledge, effectiveness, and safety of Reactive Air and Surface Treatment and associated technologies for air cleaning and surface disinfection. The main function was to create the Title, Purpose, Scope (TPS) for 185.5.
3. Formation of SPC 185.3 that is creating a document titled “Method of Testing Commercial In-Room Devices and Systems for Microorganism Removal or Inactivation in a Chamber”. This has a purpose of establishing a method of test for evaluating in-room devices and systems for microorganism removal or inactivation in a chamber. This document was being discussed by Technical Committees prior to the outbreak of COVID-19.
4. Formation of SPC 185.4 that is creating a document titled “Method of Testing In-Room Ultraviolet Devices and Systems for Microbial Inactivation on Surfaces in a Test Room”. This has a purpose of establishing a test method for evaluating the efficacy of ultraviolet disinfection systems for microbial inactivation on multiple surface locations in a test room.
5. Formation of SPC 185.5 that is creating a document titled “Method of Testing HVAC-duct mounted Devices and Systems and In-Room devices for Particle and Microorganism Removal or Inactivation in a Chamber with a Recirculating Duct System”. This has a purpose of establishing a method of test for evaluating HVAC-duct mounted devices and in-room devices and systems for particle and microorganism removal or inactivation in a chamber with a recirculating duct system.
6. ASHRAE SSPC 62.1 has started modifying its information to provide some additional details found within the ETF guidance.
7. Creation of the MTG.VIC (Ventilation for Infection Control) that is being led by Rick Hermans to review the projected research projects suggested by the ETF, specifically the Research Team.

8. The air cleaner community became much more engaged in ASHRAE in the committees. One example is that Standard 145.4P was formed to work on gaseous phase items that are not COVID-19 related.

ETF Roster and Volunteers and Contributors

Chair: Bill Bahnfleth
Vice Chair: Dennis Knight - Communications
Voting Members:

- Max Sherman - Residential
- Luke Leung - Commercial / Retail
- Stephanie Taylor - Science Background Team
- Jason Degraw - Transportation Team
- Traci Hanegan - Healthcare
- Steve Martin - Filtration & Disinfection
- Rick Hermans - Research
- Wade Conlan - Building Readiness and Resource Inventory
- Corey Metzger - Schools
- Brad Cochran - Laboratories
- John McKernan - Industrial
- Pawel Wargocki - Applications
- Walid Chakroun - Developing Economies

Corresponding / Non Voting Members

- Tim McGinn (BOD Liaison)
- James Ridenhour
- Mike Pouchak (RAC Liaison)
- Rick Heiden (STDS Liaison)
- Larry Smith (TAC Liaison)
- Chad Smith (GAC Liaison)
- Jay Kohler (as TAC Chair)
- Wayne Stopplemoor (as Standards Chair)
- Bill McQuade (BOD liaison)
- Chris Wilkins (RAC Liaison)
- Dru Crawley (STDS Liaison)
- Dustin Meredith (TAC Liaison)
- Terry Townsend (GAC Liaison)
- Walid Chakroun (GAC Liaison)
- Wei Sun (EHC Liaison)

- Alice Yates, Director of Government Affairs
- Stephanie Reiniche, Director of Technology
- Vanita Gupta, Director of Marketing

- Steve Hammerling, Manager of Technical Services

Entire listing of the ETF Volunteers can be found in Appendix C

Appendix A - Summary of Actionable Items from All Teams

Original #	Item	Group Suggesting
1, 10, 32,35, 13	Target Equivalent Outdoor Air quantity required during occupancy for reduced risk during airborne infection emergencies/ What amount of outside air and filtered/recirculated air should be delivered to healthcare spaces during a future airborne infection epidemic or as COVID-19 becomes endemic/ include residential. Flushing between occupied periods impacts.	BR, Com, HC, Ind, Res
25, 28, 27, 12, 7, 29, 38, 3, 19, 4	Combo Rec: What metrics do we need to implement and compare various air cleaning technologies? Including MERV-A vs MERV for filters to help ensure filtration efficiency throughout the life of the filters, how to determine if reactive air cleaners (RAC) are effective and safe, what is needed to understand RAC, practical comparisons, how to determine if UV (any wavelength) are effective and safe? Local use versus central station AHU? Central Station AHU impacts at different airflow quantities at different VFD speeds.	F&D, HC, Res, BR, Com
2, 4, 34, 8, 26, 31, 20, 22, 18	Specific guidance on the impact of room air distribution and layout incl occupant locations and furniture to reduce the direct transmission of infectious aerosols incl for healthcare settings. This includes the use of In Room Filter Units. Include ceiling fans (such has HVLS) Include space to space relationships. UFAD versus Overhead versus Sidewall Displacement.	BR, Com, HC, Ind, Res, Lab
37	Guidance for natural ventilation	Res
23, 30	Risk assessment for spaces and systems to determine level of engineering controls required. (Is air cleaning equivalent to a MERV-13 level appropriate in all settings to control SARS-CoV-2?) Who should ASHRAE team with to better understand the generation and infectious rates for aerosols.	F&D, Trans
	HVAC filters release particles in a size that aligns with the virus particles, from a clean to dirty filter.	
33	Energy impact due to engineering controls implemented.	Ind
21, 11	Validation: measurement of actual virus (or equivalent tracer) reduction versus the Core Recommendations and equivalent outdoor air approach predictions	Com, HC
13	What RH can a building be achieved, based on the envelope construction, can designers and operators target, in order to potentially reduce the transmission of airborne infectious disease. Better understand and communicate the impact of relative humidity on airborne infectious disease transmission	HC

Appendix B - Working Group Team Reports

B.1 Healthcare

B.2 Building Readiness

B.3 Schools

B.4 Transportation

B.5 Laboratories

B.6 Industrial

B.7 Filtration and Disinfection

B.8 Research

B.9 Residential

B.10 Commercial

ASHRAE Epidemic Task Force
Healthcare Team Report
February 12, 2022

Section 1 - Lessons Learned
As briefly as possible, please answer these four questions based on the observations and experience of the team and its members with respect to the COVID-19 pandemic and ASHRAE's response.

1. *What specific paragraphs—**if any**—of any existing ASHRAE standard or volume of the ASHRAE Handbook were particularly helpful or counterproductive in guiding the efforts of HVAC and building science professionals to reduce risks of COVID-19 transmission?*

    1. **ASHRAE Applications Handbook Chapter 9 – Healthcare**
    2. **Standard 170. Especially sections on AII rooms and tables on filtration, ACH, etc.**

    Other useful documents that are not specifically an ASHRAE standard or volume of the handbook include:

    3. **2020 revision of the ASHRAE Position Document on Infectious Aerosols**
    4. **ASHRAE Environmental Health Emerging Issue Brief, "Pandemic COVID-19 and Airborne Transmission"**
    5. **Minnesota Department of Health, "Methods for Temporary Negative Pressure Isolation"**
    6. **ASHRAE TC5.5: "Practical Guidance for Epidemic Operation of Energy Recovery Ventilation Systems".**
    7. **CDC/NIOSH: "Expedient Patient Isolation Rooms".**
    8. **CDC MMWR Guidelines for preventing the transmission of Mycobacterium tuberculosis in healthcare settings. December 30, 2005**

2. *What issues—**if any**—remain unaddressed by the most recent ASHRAE COVID-19 risk reduction guidance generated by the team?* Please state the issue clearly in a single sentence and provide the reason(s) that the issue should be resolved by others to reduce risks of airborne infection in the future. Keep in mind that funding sometimes allows or prevents such volunteer efforts. When the team is aware of potential funding sources to support volunteer deliberation and analysis, please note the names and contact information for specific personnel at the organizations that may be able to provide such support.
    1. **We should be partnering with ASHE closely on topics and funding for future research. Contact Jonathan Flannery, jflannery@asha.org, 501-813-2400.**
    2. **Does SARS-CoV-2 transmit through HVAC systems in a manner that allows for subsequent infectivity? If so, under what conditions? This is needed to develop strategies for preventing HAIs.**
    3. **Need improved guidance for use (placement especially) of HEPA filter units in patient rooms and other healthcare spaces. This is needed to improve effectiveness of HEPA units as an investment in risk reduction.**
    4. **Our Healthcare FAQs could use updating based on new knowledge and on what would be most helpful to readers.**
    5. **What amount of outside air and filtered/recirculated air should be delivered to healthcare spaces during a future airborne infection epidemic or as COVID-19 becomes endemic? This is needed to reduce infection risk, potentially reduce energy**

consumption, and provide targets for facilities that wish to upgrade their HVAC systems (or design new facilities) to achieve levels that are higher than their current systems can support.

6. **Provide more detailed guidance on verification and validation requirements when implementing epidemic measures. For example, in situ performance testing of portable HEPA units. This is needed to confirm that implemented measures have been correctly set up and are providing the expected performance.**
7. **Provide more practical comparisons of air filtering and cleaning technologies to assist with evaluations by HVAC engineers, architects, and owners. This is needed to capture new research (for example methods for testing and rating) and to reduce confusion when evaluating options.**
8. **Better understand and communicate the impact of relative humidity on airborne infectious disease transmission. This is needed to more firmly establish steps that can be taken to improve risk and to raise awareness of this approach, when found to be effective.**
9. **Provide more specific guidance on air distribution in different healthcare settings and its impact on the level of cleanliness in the breathing zone. Develop methods for evaluation. This is needed to reduce risk and more effectively utilize the energy expended to ventilate and condition healthcare spaces.**

3. *Which risk reduction guidance generated by the team for COVID-19—**if any**—might also be appropriate for inclusion in existing or new ASHRAE handbook chapter or standards?* (Please provide the specific wording of the guidance, plus the reason(s) why and where it should be included in persistent ASHRAE guidance. Be aware that once published, ASHRAE guidance is sometimes unquestioned and becomes republished with little or no review for decades, during which there may be little or no risk of a pandemic.)

    1. **Dental section added to handbook (can be subset of healthcare). Huge exposure area and lots of demand for input by ASHRAE from dental community. Should we be adding dental spaces to Std. 170 or other ASHRAE document?**
    2. **Residential Healthcare spaces (sections to assist with patient isolation, filtration). This environment was where the majority of infections leading to death occurred. A very vulnerable population.**
    3. **Healthcare section – Need to select what should go in handbook. Std. 170 is also considering if any changes should be made based on the guidance. So far not much, but the TC9.6 ID subcommittee should have a specific discussion about it.**

4. *Other **pandemic-related** issues—**if any**—outside the direct scope of this team's responsibilities that merit discussion or resolution by the overall ETF to help the Board of Directors fulfill ASHRAE's vision: A healthy and sustainable built environment for all.*

    1. **Develop special publication(s) to capture guidance.**
    2. **Develop pathway for ASHRAE to sidestep the typical process and instead become nimble in evaluating and conducting research during an epidemic, when time is of the essence.**

Section 2 – Team-Generated Guidance
To assist transition of the maintenance of COVID-19 guidance to technical committees, please list all guidance documents developed by this team and the issue date of the final version. Include the final versions approved and published by ASHRAE in the Appendix.

Healthcare, Dental, and Residential Healthcare .ppt slide decks
Alternate Care Sites HVAC Guidebook, co-authored with USACE
Healthcare FAQs currently on ETF website

Section 3 – Transition Plan
Please list which entities in ASHRAE (Technical Committees, Standing Committees, Standard and Guideline Committees, etc.) will take over the work of the team and briefly summarize what steps have been taken to initiate the transfer of responsibility.

Transfer oversight to TC9.6. The Infectious Diseases subcommittee will be responsible for specific implementation of tasks and coordination with Std. 170. Consider updates to the Handbook chapter on healthcare, FAQs, and HVAC Design Manual for Hospitals & Clinics (upcoming 3rd Edition). Consider also future publications, programs/presentations, research recommendations, standards revisions, and training/classes.

A brief discussion of this draft report was discussed at the Infectious Diseases subcommittee meeting on 1-27-22 and at the main TC9.6 Healthcare meeting on 1-30-22. A follow up videoconference meeting with the ID subcommittee to refine the draft before final submission will be held later in February 2022 to continue work on the transition plan.

Collaboration with the Environmental Health Committee and with MTG Ventilation for Infection Control.

Appendix
Section 2 – Team-Generated Guidance
Final versions of all guidance documents:

Healthcare Facilities (1/19/2022) - https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-healthcare-c19-guidance.pdf

Dental Facilities (1/19/2022) - https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-dental-c19-guidance.pdf

Healthcare FAQs - https://www.ashrae.org/technical-resources/healthcare-faq

Appendix 2 - Technical References
Please provide key peer-reviewed bibliographic references (including DOI numbers) that the team believes may be useful to future ASHRAE efforts to help reduce risks from airborne transmission. For

each reference, please also include one or two sentences explaining why and how the reference may be useful.

Executive Summary

This report is intended to help improve the Society's response to the life-safety threats presented by the COVID-19 pandemic. It can also assist ASHRAE technical committees as they seek to improve ASHRAE standards and guidance with respect to indoor air quality (IAQ) and to reducing risks of indoor transmission of airborne pathogens and infectious aerosols.

The report documents the collected experiences and recommendations of the building readiness team of ASHRAE's COVID-19 Epidemic Task Force. This report reflects the building readiness guide (BRG) team's perspectives and recommendations.
The building readiness team built four technical guidance documents, two tools (infographic and equivalent air calculator), worked with technical groups to create two other technical guidance documents, and answered multiple questions on the FAQ page. This guidance referenced twenty existing ASHRAE documents and thirteen external documents.

This guide has information that could provide pertinent technical information to be incorporated as concerns with a pandemic, if not already in their documents, for twenty-nine (29) ASHRAE Technical Groups (SPC, GPC, TC, MTG).

The following are what this team believes are open issues:

- Target Equivalent Outdoor Air quantity required during occupancy for reduced risk during airborne infection emergencies
- Design guidance on the impact of room air distribution to reduce the direct transmission of infectious aerosols
- Impact of airflow other than design maximum of the HVAC systems ability to remove particles and infectious aerosols.
- Impact of humidity and dirt on MERV rated filters versus MERV-A.
- Impact of Flushing Spaces on Contaminants and Particles

The following are issues beyond this guidance that it believes ASHRAE should address:

- Rather than "ventilation air", ETF guidance should use the term "equivalent outdoor air" along with a clear definition and explanation of that term.
- Equivalent outdoor air target values (ACHe or CFM/SF above Code) need to be defined so building operators, owners, designers, TAB, CxP have the appropriate goal for systems performance
- Archive airborne pandemic lessons in a special publication
- ASHRAE Understand the value and impact on IEQ of proper existing building commissioning, and Testing, Adjust, Balance (TAB) efforts
- Develop method of test for air cleaning devices like Std 185 for UV
- Provide guidance and teaching the value of Health, Safety, and Welfare (HSW) as compared with energy impact

ASHRAE ETF – Building Readiness Transition Report
January 14, 2022

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Team-Generated Guidance

This team has developed the following text, graphics, and tools that ASHRAE standing and technical committees may wish to consider when developing more durable, long-term standards and guidance:

- **Building Readiness guidance main page**. (https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-building-readiness.pdf)
- **One-page guidance document for GUIDANCE FOR RE-OPENING BUILDINGS**. (https://www.ashrae.org/file%20library/technical%20resources/covid-19/guidance-for-re-opening-buildings.pdf)
- **Exhaust Air Reentrainment Guide** (https://www.ashrae.org/file%20library/technical%20resources/covid-19/exhaust-re-entrainment-guide.pdf)
- **Impact of Increasing Space Relative Humidity in Winter Mode for Reducing COVID-19 Transmission** (ETF Reviewed. TC 1.12 Reviewing. Will be Published in Feb 2022)
- **ASHRAE ETF Infographic** (https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-covid19-infographic-.pdf)
- **Equivalent Outdoor Air Calculator – TOOL –** (https://docs.google.com/spreadsheets/d/1GUCcjAyhzrTATHD8SQvNcF7JnuWKpadSVT6LA_8SUII/edit#gid=0)
- **The Practical Guidance for Epidemic Operation of Energy Recovery Ventilation Systems (with TC 5.5)** (https://www.ashrae.org/file%20library/technical%20resources/covid-19/practical-guidance-for-epidemic-operation-of-ervs.pdf)
- **Practical Guidance for Vaccine Refrigerated Transportation and Storage – Created by the REF-CPCC Committee with the help of BRG** (https://www.ashrae.org/file%20library/technical%20resources/covid-19/practical-guidance-for-vaccine-refrigerated-transportation-and-storage-abstract.pdf)
- **Frequently asked questions and answers for re-opening or shuttering buildings:**
  - HVAC System Operation During Building Shutdown FAQ
  - How to Return the HVAC System to Normal Operation FAQ

Section 1 - Lessons Learned

1. Reference Documents

ASHRAE standards, handbook chapters or special publications that team members found helpful for advising the public and developing residential COVID guidance.
The following is a listing of ASHRAE documents and non-ASHRAE documents that were used in building the guidance of this team. There are notes as to the importance of these documents to the guidance.

The following ASHRAE documents were used to help build the guidance documents:

- ASHRAE Standard 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
  - Impact of filter ratings and droplet nuclei capture efficiency.
- ASHRAE Standards 62.1 – Ventilation for Acceptable Indoor Air Quality
  - Table 6-4 – for room air distribution effectiveness
  - For Code minimum OA requirements using the standard's prescriptive tables
- ASHRAE Standard 111-2008 (RA 2017) - Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation and Air-Conditioning Systems
  - For evaluation of existing systems and the importance of proper TAB
- ASHRAE Standard 180-2018: Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems
  - Impact of how systems can be maintained, or not, by facilities to improve their performance before the next pandemic
  - Developing checklists for the inspection of existing HVAC systems with a focus toward their ability to provide adequate filtration, ventilation, and, if necessary, air cleaning, with respect to mitigating the spread of infectious aerosols and particulates.
- ASHRAE Standard 188-2018: Legionellosis: Risk Management for Building Water Systems
  - Water quality impact of shuttering a building and re-opening
- ASHRAE Guideline 1.4-2019: Preparing Systems Manuals for Facilities
  - Proper method to document systems operation for pandemic modes
- ASHRAE Guideline 11-2018 – Filed Testing of HVAC Control Components
  - Proper check for existing systems operation and documenting control system and BAS capabilities for both on-site and remote monitoring of system function and performance.

- Guideline 12-2020 - Managing the Risk of Legionellosis Associated with Building Water Systems
  - Water quality impact of shuttering a building and re-opening
- ASHRAE Guideline 36-2018 - High-Performance Sequences of Operation for HVAC Systems
  - Methods of control for systems that could be adopted to reduce energy during a pandemic
- 2019 ASHRAE Handbook—APPLICATIONS - Chapter 62 - Ultraviolet air and surface treatment
  - UV guidance for inactivating viruses and bacteria
- 2020 ASHRAE Handbook – HVAC Systems and Equipment – Chapter 26 – Air-to-Air Energy Recovery Equipment
  - Understanding of energy recovery wheels and thermal plates potential impact on air quality
- 2016 ASHRAE Handbook – HVAC Systems and Equipment – Chapter 17 – Ultraviolet Lamp Systems
  - UV guidance for inactivating viruses and bacteria
- ASHRAE RP-1088 titled Coordinate and Analyze Interlaboratory Testing of Filters under ASHRAE Standard 52.2 to Determine the Adequacy of the Apparatus Qualification Tests dated May 12, 2005, completed by RTI International
  - Impact of filter ratings and the capture droplet nuclei efficiency.
- ETF Filtration and Disinfection Guidance
- ETF Exhaust Air Reentrainment Guide
- ETF Commercial Building Guide
- ETF Practical Guidance for Epidemic Operations of Energy Recovery Ventilation Systems
  - Authored by TC 5-5 (Air-to-Air Energy Recovery) and Building Readiness Team
- ASHRAE Position Document on Infectious Aerosols
- ASHRAE Position Document on Filtration and Air Cleaning
- ASHRAE Journal article: Ultraviolet Germicidal Irradiation - Current Best Practices (2008, Martin et al)
  - UV guidance for inactivating virus and bacteria

The following items are non-ASHRAE Publications that were used in the development of this document:

- Tang, J., W. Bahnfleth, P. Bluyssen, et al. 2021. “Dismantling myths on the airborne transmission of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2).” J Hosp Infect. 110:89 – 96. https://doi.org/10.1016/j.jhin.2020.12.022
    - UV guidance for inactivating virus and bacteria
- Impact of filter ratings and droplet nuclei capture efficiency. Lindsley, W, F. Blachere, K. Davis, T. Pearce, et al. 2010. “Distribution of airborne infuenza virus and respiratory syncytial virus in an urgent care medical clinic.” Clin Infect Dis. 50(5):693 – 698.
    - UV guidance for inactivating virus and bacteria
    - Impact of filter ratings and droplet nuclei capture efficiency.
- Blachere, F., W. Lindsley, T. Pearce, S. Anderson, et al. 2009. “Measurement of airborne infuenza virus in a hospital emergency department.” Clin Infect Dis. 48(4):438 – 440.
    - UV guidance for inactivating virus and bacteria
    - Impact of filter ratings and droplet nuclei capture efficiency.
- Lindsley, W., F. Blachere, R. Thewlis, A. Vishnu, et al. 2010. “Measurements of airborne infuenza virus in aerosol particles from human coughs.” PLoS One 5(11): e15100.
    - UV guidance for inactivating virus and bacteria
    - Impact of filter ratings and droplet nuclei capture efficiency.
- Yang, W., S. Elankumaran, L. Marr. 2011. “Concentrations and size distributions of airborne infuenza A viruses measured indoors at a health centre, a day-care centre and on aeroplanes.” J R Soc Interface 8(61):1176 – 1184.
    - UV guidance for inactivating virus and bacteria
    - Filter Impact of filter ratings and droplet nuclei capture efficiency.
- Noti, J., W. Lindsley, F. Blachere, G. Cao, et al. 2012. “Detection of infectious infuenza virus in cough aerosols generated in a simulated patient examination room.” Clin Infect Dis. 54(11):1569 – 1577.
    - UV guidance for inactivating virus and bacteria
    - Impact of filter ratings and droplet nuclei capture efficiency.
- Azimi, P., B. Stephens. 2013. “HVAC filtration for controlling infectious airborne disease transmission in indoor environments: Predicting risk reductions and operational costs.” Building and Environment 70(Dec.):150 –160. https://doi.org/10.1016/j.buildenv.2013.08.025
    - UV guidance for inactivating virus and bacteria

  - Impact of filter ratings and droplet nuclei capture efficiency.
- AHAM. 2015. “ANSI/AHAM AC-1-2015, Method for Measuring Performance of Portable Household Electric Room Air Cleaners.” Association of Household Appliance Manufacturers.
  - In room air cleaner performance
- NIOSH Guidelines – 2009
  - Hierarchy of controls
- American Water Works Association (AWWA) - Shutoffs and Return to Service Guidance (https://www.awwa.org/Resources-Tools/Resource-Topics/Coronavirus#10681543-shutoffs-and-return-to-service-guidance)
  - Water quality for shuttering and re-opening buildings
- US Environmental Protection Agency - Information on Maintaining or Restoring Water Quality in Buildings with Low or No Use (https://www.epa.gov/coronavirus/information-maintaining-or-restoring-water-quality-buildings-low-or-no-use)
  - Water quality for shuttering and re-opening buildings
- Purdue University – Center for Plumbing Safety, Water Quality in Low Occupancy and Shutdown Buildings (https://engineering.purdue.edu/PlumbingSafety/covid19/building-water-safety-study)
  - Water quality for shuttering and re-opening buildings
- SRP – Vampire of Phantom Appliances – (https://www.srpnet.com/energy/DIY/vampire.aspx)
  - Power impact on plug loads when a building is shuttered
- NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
  - Power impact on plug loads when a building is shuttered

2. Open Issues

These are the issues that remain unaddressed by COVID-19 guidance as of November 2021.

The following are items that this team found to be unaddressed by our most recent guidance:

- **Target Equivalent Outdoor Air quantity required during occupancy for reduced risk during airborne infection emergencies**. We lack an answer that would allow the industry to understand how to evaluate and upgrade their systems to achieve these targets.

  Recommendation: Since 62.1 is for "Acceptable" IAQ should there be a SPC formed for "Disaster" IAQ to develop the guidance to provide new or temporary targets for various disaster scenarios (flood, hurricanes, wildfires, infectious diseases, etc.). Even if it is a tool for people to put in parameters to get the ACHe or additional CFM/SF of equivalent OA for their situation or CADR. One thing to note from one of the member's experiences reviewing proposed engineering solutions for HVAC upgrades in response to the US Government's CARES Act and EESER Funding programs is that it appears that some engineers are using the ASHRAE 62.1 IAQP to apply emerging technologies and possibly unproven technologies to, in some cases, reduce the amount of ventilation air being supplied to occupied spaces in K-12 schools to as little as 30-40% of the ASHRAE 62.1 VRP prescriptive table quantities using an arbitrary handful of contaminants of concern in the evaluations and not addressing particulates at all. The engineers also often quote the 5000 ppm 8-hour TEL concentration of CO2 cited in NIOSH, OSHA and the ACGIH guidance for adult in the workplace listed in the 62.1 informative appendices as an ASHRAE limit and performing their evaluations under the IAQP and allowing classroom CO2 levels to exceed 2500-3000 ppm. In addition, there seems to be a growing body of research such as the work that is being done by the TH Chan School for Public Health at Harvard and Dr. Joe Allen that suggests that CO2 may be a contaminant of concern and that CO2 levels greater than about 1500 ppm may have significant effects on cognition, learning and job performance. ASHRAE needs to be participating in and/or sponsoring high quality, independent, third-party research into these areas and topics of concern and working with allied organizations to determine whether our prescriptive ventilation rates are adequate, too little, or excessive and to provide better guidance on and possible revisions to the IAQP in support of whatever the findings for the suggested research are.

  Building Readiness Team understands that the term "Equivalent Outdoor Air" might need to be changed to be better accepted in the industry. There are a few names, but none that the team like better, such as Clean Air or NAIDE, so it used the equivalent outdoor air. Part of this work could be to have a better name and acronym.

- **Design guidance on the impact of room air distribution to reduce the direct transmission of infectious aerosols**. It became clear that during this pandemic how air moved through the space impacted who would become infected. Also, our

assumptions in most engineering tools and practices are based on “well mixed” air within spaces. However, we, as practicing professionals, have little control over the air distribution configurations being laid out and applied in most commercial buildings and the reality is that most spaces deviate significantly from the well mixed scenario. We need to again sponsor good research on the correction factors that should be used to correct for actual, in place air distribution systems in buildings of all occupancy types.

Recommendation: Have TC 5.3 – Room Air Distribution and/or MTG – Air Change Rate and/or TC-4.10 – Indoor Environmental Modeling - work on guidance for air distribution impact on risk of infection that can be implemented in designs to avoid issues in the next pandemic.

- **Impact of airflow other than design maximum of the HVAC systems ability to remove particles and infectious aerosols.** The guidance talks about the use of airflow, but it is obvious that the actual airflow versus design impacts the systems ability to mitigate transmission.

  Recommendation: Have TC 5.3 – Room Air Distribution and/or MTG – Air Change Rate and/or TC-4.10 – Indoor Environmental Modeling – work on guidance to discuss this issue.

- **Impact of humidity and dirt on MERV rated filters versus MERV-A.** The guidance talks about the use of higher rated MERV filters but does not expand on the impact of using MERV-A versus MERV filters.

  Recommendation: Have SPC 52.2 – work on guidance and research to identify the causes and the actual impact of varying RH levels on filters and filter performance prior to use.

- **Impact of Flushing Spaces on Contaminants and Particles**. We did not find information or studies to show the impact of flushing on the space, between occupancies, and the actual reduction in particles over time. This is meant to prove out models of spaces and systems with real world case studies.

  Recommendation: Have TC 5.3 – Room Air Distribution and/or MTG – Air Change Rate and/or TC-4.10 – Indoor Environmental Modeling and/or SPC 62.1 work on potential research and the impact of flushing.

3. Information for other ASHRAE Groups

   What risk reduction guidance generated by this team for COVID-19 should be reviewed by other ASHRAE bodies to see if they believe it should be included in their handbook chapters, guidelines, or standards.

This is organized by ASHRAE committee or group that could potentially evaluate the materials for them to include. The applicable page of the documentation is noted as "# to ## of 143" for the Building Readiness Guide to indicate the page of interest for that ASHRAE group.

TC 1.4 – Control Theory and Application

- Pages 11 to 15 of 143: This deals with the evaluation of an existing controls systems as well as the ability for remote access. It is likely that their documents include this information but might be well to be presented in Epidemic or Disaster Mode of efforts.
- Page 21 of 143: methods for increased ventilation control strategies.
- Pages 102 to 109 of 143: Deals with shuttering a building and the steps to go through to prevent mold, legionellosis, and wasted energy.
- Pages 112 to 127 of 143: Talks about the evaluation prior to re-occupying a facility that has been shuttered.

TC 1.12 – Moisture Management in Buildings

- Impact of Increasing Space Relative Humidity in Winter Mode for Reducing COVID-19 Transmission– this guide, in review for publication, covers the evaluation of increasing RH and the impact on the existing building envelope.

TC 2.1 – Physiology and Human Environment

- Pages 23 to 25 of 143: Deals with the pre- or post- flushing of spaces to reduce contaminants.
- Pages 26 to 35: Deals with how to calculate Equivalent Outdoor Air for flushing of spaces
- Equivalent Outdoor Air Calculator Tool: This is a practical tool to help determine the impact of the HVAC system for creating "clean air". If we expand such a tool, it should be robust and include a significant number of modifiable inputs for things that can affect and influence a system or device's ability to improve a spaces IAQ and disinfection.

TC 2.3 - Gaseous Air Contaminants and Gas Contaminant Removal Equipment

- Pages 23 to 25 of 143: Deals with the pre- or post- flushing of spaces to reduce contaminants.

TC 2.4 - Particulate Air Contaminants and Particulate Contaminant Removal Equipment

- Pages 23 to 25 of 143: Deals with the pre- or post- flushing of spaces to reduce contaminants.
- Pages 37 to 43: Methodology to identify the target particle size of virus for filters to remove viable particles. Droplet nuclei filter efficiency approach.
- Pages 44 to 49 of 143: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters.

TC 2.9 – Ultraviolet Air and Surface Treatment

- Page 89 of 143: No new information presented. However, it would be good to have some additional practical application and irradiance levels of UV on infectious aerosols and to have targets for unknown items.

TC 2.10 – Resilience and Security

- Entire document should be reviewed to see how it fits their scope.
- Pages 102 to 109 of 143: Deals with shuttering a building and the steps to go through to prevent mold, legionellosis, and wasted energy.

TC 4.3 – Ventilation Requirements and Infiltration

- Pages 23 to 25 of 143: Deals with the pre- or post- flushing of spaces to reduce contaminants.
- Pages 26 to 35: Deals with how to calculate Equivalent Outdoor Air for flushing of spaces
- Equivalent Outdoor Air Calculator Tool: This is a practical tool to help determine the impact of the HVAC system for creating “clean air”
- Page 51 of 143: Deals with re-entrainment evaluation. We need better guidance and tools on how to evaluate this subject with respect to a particular disaster or epidemic being considered or present at the time the evaluation is needed. I.e., disaster specific evaluation tools and mitigation strategies.
- Exhaust Air Reentrainment Guide – this guide covers the evaluation of re-entrainment

TC 4.4 Building Materials and Building Envelope Performance

- Impact of Increasing Space Relative Humidity in Winter Mode for Reducing COVID-19 Transmission– this guide, in review for publication, covers the evaluation of increasing RH and the impact on the existing building envelope.

TC 5.3 – Room Air Distribution

- Nothing to review as the information for impact of room air distribution with regards to air distribution placement, velocities, and other items impact on infectious aerosols.

TC 5.5 – Air-to-Air Energy Recovery

- Page 51 of 143: Deals with re-entrainment evaluation.
- Page 52 to 88 of 143: Excerpts from the • "The Practical Guidance for Epidemic Operation of Energy Recovery Ventilation Systems (with TC 5.5)" that was built by TC-5.5 and the Building Readiness Team to get published on the ETF site.
- Exhaust Air Reentrainment Guide – this guide covers the evaluation of re-entrainment

TC 6.6 – Service Water Heating Systems

- Pages 91 to 93 of 143: We used excerpts from G12 and S188 for water. It would be good to have some additional guidance on shuttering buildings and the water testing to be done when re-opened.
- Pages 102 to 109 of 143: Deals with shuttering a building and the steps to go through to prevent mold, legionellosis, and wasted energy.
- Pages 112 to 127 of 143: Talks about the evaluation prior to re-occupying a facility that has been shuttered.

TC 7.3 – Operation, Maintenance and Cost Management

- Pages 44 to 49 of 143: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters. Doing this work without increasing operating cost is big.
- Pages 102 to 109 of 143: Deals with shuttering a building and the steps to go through to prevent mold, legionellosis, and wasted energy.
- Pages 112 to 127 of 143: Talks about the evaluation prior to re-occupying a facility that has been shuttered.
- Pages 128 to 138 of 143: Deals with considerations of operation of the systems, maintenance, mitigation strategies and other items that were not able to be done during the pandemic and items to evaluate for renovations and improvements.

TC 7.7 – Testing and Balancing

- Pages 44 to 49 of 143: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters that TAB might want to explain the approach on how to do this effort.
- Pages 112 to 127 of 143: Talks about the evaluation prior to re-occupying a facility that has been shuttered.

TC 7.8 – Owning and Operating Costs

- Pages 44 to 49 of 143: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters. Doing this work without increasing operating cost is big.
- Pages 102 to 109 of 143: Deals with shuttering a building and the steps to go through to prevent mold, legionellosis, and wasted energy.
- Pages 112 to 127 of 143: Talks about the evaluation prior to re-occupying a facility that has been shuttered.
- Pages 128 to 138 of 143: Deals with considerations of operation of the systems, maintenance, mitigation strategies and other items that were not able to be done during the pandemic and items to evaluate for renovations and improvements.

TC 7.9 – Building Commissioning

- Pages 102 to 109 of 143: Deals with shuttering a building and the steps to go through to prevent mold, legionellosis, and wasted energy.
- Pages 112 to 127 of 143: Talks about the evaluation prior to re-occupying a facility that has been shuttered.

TC 8.4 – Air-to-Refrigerant Heat Transfer Equipment (S&E Chapters 23 and 27)

- Pages 18 to 20 of 143: This deals with the impact of increasing ventilation on an existing cooling coil for both cooling and heating coils. It also talks about the impact of glycol which is likely in their materials but was not easily found.

TC 9.1 – Large Building Air-Conditioning Systems (S&E Chapter 4)

- Pages 44 to 49 of 143: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters.

SPC 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

- Page 36 of 143: General information on filters. Need to expand MERV-A discussion.
- Pages 37 to 43: Methodology to identify the target particle size of virus for filters to remove viable particles. Droplet nuclei filter efficiency approach.

SSPC 62.1 – Ventilation for Acceptable Indoor Air Quality

- Pages 23 to 25 of 143: Deals with the pre- or post- flushing of spaces to reduce contaminants.
- Pages 26 to 35: Deals with how to calculate Equivalent Outdoor Air for flushing of spaces

- Equivalent Outdoor Air Calculator Tool: This is a practical tool to help determine the impact of the HVAC system for creating "clean air"

SPC 160-2016 -- Criteria for Moisture-Control Design Analysis in Buildings

- Impact of Increasing Space Relative Humidity in Winter Mode for Reducing COVID-19 Transmission– this guide, in review for publication, covers the evaluation of increasing RH and the impact on the existing building envelope.

SPC 180-2018: Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems

- Pages 94 to 101 of 143: Deals with checking maintenance for pandemic items versus normal operation.
- Pages 102 to 109 of 143: Deals with shuttering a building and the steps to go through to prevent mold, legionellosis, and wasted energy.
- Pages 112 to 127 of 143: Talks about the evaluation prior to re-occupying a facility that has been shuttered.
- Pages 128 to 138 of 143: Deals with considerations of operation of the systems, maintenance, mitigation strategies and other items that were not able to be done during the pandemic and items to evaluate for renovations and improvements.

SPC 188-2018: Legionellosis: Risk Management for Building Water Systems

- Pages 91 to 93 of 143: We used excerpts from G12 and S188 for water. It would be good to have some additional guidance on shuttering buildings and the water testing to be done when re-opened.
- Pages 102 to 109 of 143: Deals with shuttering a building and the steps to go through to prevent mold, legionellosis, and wasted energy.
- Pages 112 to 127 of 143: Talks about the evaluation prior to re-occupying a facility that has been shuttered.

SSPC 300 Building Commissioning

- Existing Building Cx Docs
    - Pages 102 to 109 of 143: Deals with shuttering a building and the steps to go through to prevent mold, legionellosis, and wasted energy.
    - Pages 112 to 127 of 143: Talks about the evaluation prior to re-occupying a facility that has been shuttered.
- GPC 1.4

  - Pages 102 to 109 of 143: Deals with shuttering a building and the steps to go through to prevent mold, legionellosis, and wasted energy.
  - Page 110 of 143: Discusses incorporating Pandemic Mode into the Systems Manual.
  - Page 139 of 143: reiterates the need for pandemic mode in a system's manual.
- New Building Cx Docs
  - Page 110 of 143: Discusses incorporating Pandemic Mode into the Systems Manual.

GPC 12-2020 - Managing the Risk of Legionellosis Associated with Building Water Systems

- Pages 91 to 93 of 143: We used excerpts from G12 and S188 for water. It would be good to have some additional guidance on shuttering buildings and the water testing to be done when re-opened.
- Pages 102 to 109 of 143: Deals with shuttering a building and the steps to go through to prevent mold, legionellosis, and wasted energy.
- Pages 112 to 127 of 143: Talks about the evaluation prior to re-occupying a facility that has been shuttered.

GPC 36-2021 - High-Performance Sequences of Operation for HVAC Systems

- Page 21 of 143: methods for increased ventilation control strategies.
- Pages 102 to 109 of 143: Deals with shuttering a building and the steps to go through to prevent mold, legionellosis, and wasted energy.

MTG.ACR – Air Change Rate

- Pages 23 to 25 of 143: Deals with the pre- or post- flushing of spaces to reduce contaminants.
- Pages 26 to 35: Deals with how to calculate Equivalent Outdoor Air for flushing of spaces
- Equivalent Outdoor Air Calculator Tool: This is a practical tool to help determine the impact of the HVAC system for creating "clean air"

MTG.EBO – Effective Building Operations

- Pages 23 to 25 of 143: Deals with the pre- or post- flushing of spaces to reduce contaminants.
- Pages 26 to 35: Deals with how to calculate Equivalent Outdoor Air for flushing of spaces

- Equivalent Outdoor Air Calculator Tool: This is a practical tool to help determine the impact of the HVAC system for creating “clean air”
- Pages 44 to 49 of 143: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters.
- Pages 91 to 93 of 143: We used excerpts from G12 and S188 for water. It would be good to have some additional guidance on shuttering buildings and the water testing to be done when re-opened.
- Pages 102 to 109 of 143: Deals with shuttering a building and the steps to go through to prevent mold, legionellosis, and wasted energy.
- Pages 112 to 127 of 143: Talks about the evaluation prior to re-occupying a facility that has been shuttered.
- Page 51 of 143: Deals with re-entrainment evaluation.
- Page 52 to 88 of 143: Excerpts from the • “The Practical Guidance for Epidemic Operation of Energy Recovery Ventilation Systems (with TC 5.5)” that was built by TC-5.5 and the Building Readiness Team to get published on the ETF site.
- Exhaust Air Reentrainment Guide – this guide covers the evaluation of re-entrainment

MTG.HWBE – Health and Wellness in the Built Environment

- Pages 23 to 25 of 143: Deals with the pre- or post- flushing of spaces to reduce contaminants.
- Pages 26 to 35: Deals with how to calculate Equivalent Outdoor Air for flushing of spaces
- Equivalent Outdoor Air Calculator Tool: This is a practical tool to help determine the impact of the HVAC system for creating “clean air”
- Page 51 of 143: Deals with re-entrainment evaluation.
- Page 52 to 88 of 143: Excerpts from the • “The Practical Guidance for Epidemic Operation of Energy Recovery Ventilation Systems (with TC 5.5)” that was built by TC-5.5 and the Building Readiness Team to get published on the ETF site.
- Exhaust Air Reentrainment Guide – this guide covers the evaluation of re-entrainment

4. Issues Beyond this Guidance

Issues outside this team's assigned responsibilities that affect the effectiveness of ASHRAE's pandemic response.

To improve epidemic response, the ASHRAE Board of Directors may wish to consider these observations and suggestions:

- **Rather than "ventilation air", ETF guidance should use the term "equivalent outdoor air" along with a clear definition and explanation of that term.** Our team members believe that there is widespread confusion about the combination of the impact of air cleaning (fitters, UV, etc.) on recirculated air in addition to outdoor air to dilute and remove airborne virus. We believe that a universal and publically comprehensible definition and explanation is important, but beyond the scope of our team's responsibilities.

  Recommendation: The ETF should consider using the term "equivalent outdoor air." We suggest that a universal definition (applicable only to COVID-19 guidance) could be as provided in the Building Readiness Guide with the applicable Equivalent Outdoor Air Calculator Tool.

- **Equivalent outdoor air target values (ACHe or CFM/SF above Code) need to be defined so building operators, owners, designers, TAB, CxP have the appropriate goal for systems performance.** Public and professional expectations remain that ASHRAE should determine how much equivalent outdoor air will "keep people safer".

  The ETF's scientific team made extensive assessments of available outbreak studies and developed a complex but potentially credible methodology for recommending ventilation rates. Unfortunately, the number of assumptions and their uncertainty does not allow establishment of air flow rates that are physically possible and economically practical.

  Recommendation: Build a tool to utilize the scientific application teams efforts so that people can create their own target with the variables to be selected by the user. This tool and the goals are limiting the impact of the ETF on how systems should be modified for each situation.

- **Archive airborne pandemic lessons in a special publication.** To speed and improve future pandemic response by the worldwide HVAC community, a new special publication is probably the logical place to archive ASHRAE's airborne infection guidance. We consider a special publication to be a better option than a handbook chapter for two reasons: information about pandemics is not generally useful at other times, and a special publication can record the specifics of this and similar pandemics for reference as an historical event, rather than attempting to generalize guidance that may or may not be useful for future pandemics. Development of this special publication is probably best

led by a new MTG that is comprised of the following: Environmental Health Committee, SPC 55.2, 62.1, 62.2, 185 and 300 and TCs 6.6, 4.3, 5.4, 7.9, 7.3, 7.7, and 7.8.

Recommendation: The MTG should create an ASHRAE encompassing new special publication that focuses on the lessons learned about risk reduction by providing specific examples of documented events during recent airborne pandemics, e.g.: SARS-CoV-1, MERS and SARS-CoV-2 and SARS-CoV-2 (Delta). The ETF documents, referenced documents, and the transition reports would provide a lot of source material.

- **ASHRAE Understand the value and impact on IEQ of proper existing building commissioning, and Testing, Adjust, Balance (TAB) efforts.** Existing systems fall out of calibration and control over time impacting energy and IEQ. In addition, existing buildings may lack the IAQ measuring components that are being recommended due to this pandemic.

  Recommendation: ASHRAE stress the impact of the Cx and TAB process on more than energy. Many studies have evaluated the impact of these items on energy but rarely is IEQ the focus of the study and their impact on improved IEQ. Fund research to evaluate the impact of existing building commissioning and proper TAB on the built environment IEQ.

- **Develop method of test for air cleaning devices like Std 185 for UV.** Existing systems fall out of calibration and control over time impacting energy and IEQ. In addition, existing buildings may lack the IAQ measuring components that are being recommended due to this pandemic.

  Recommendation: ASHRAE needs solid research and independent third-party evaluations of all new and existing air cleaning technologies and method of test standards to rapidly test any emerging technologies and new disaster scenarios present themselves in the future.

- **Provide guidance and teaching the value of Health, Safety, and Welfare (HSW) as compared with energy impact.** While energy efficiency is important, we should spend some time educating the public on the importance of HVAC systems on the health, safety, and welfare (HSW) of building occupants and that systems should provide for HSW first and be as efficient as possible while satisfying the basic HSW requirements.

  Recommendation:

  Have the Environmental Health Committee work with other ASHRAE Technical Groups to develop training on the impact of HSW and energy. This could be applicable to the common systems found in buildings and the optimization measures people are using to reduce energy.

Section 2 – List of Team-Generated Guidance

Information included at the front of the document so people reading this report are aware of the documents being referenced in Section 1 recommendations.

Section 3 – Technical References

See Sections 1.1 for the listing of references used by this team's guidance.

ASHRAE ETF – School Team Transition Report

Executive Summary

This report is intended to help improve the Society's response to the life-safety threats presented by the COVID-19 pandemic. It can also assist ASHRAE technical committees as they seek to improve ASHRAE standards and guidance with respect to indoor air quality (IAQ) and to reducing risks of indoor transmission of airborne pathogens and infectious aerosols.

The report documents the collected experiences and recommendations of the schools team of ASHRAE's COVID-19 Epidemic Task Force. This report reflects the perspectives and recommendations of the schools team, primarily focused on the schools and universities guide (SUG).
The schools team built two technical guidance documents, worked with technical groups to create two other technical guidance documents, and answered multiple questions on the FAQ page. This guidance referenced six existing ASHRAE documents and twelve external documents.

This guide has information that could provide pertinent technical information to be incorporated as concerns with a pandemic, if not already in their documents, for seven (7) ASHRAE Technical Groups (SPC, GPC, TC, MTG).

The following are what this team believes are open issues:

- Target Ventilation or Equivalent Outdoor Air quantity required during occupancy for reduced risk during airborne infection emergencies, considering different space types typically found in schools and universities
- Design guidance on the impact of room air distribution to reduce the direct transmission of infectious aerosols, considering different space types used in schools and universities and different operating conditions (e.g., heating vs. cooling)
- Impact of airflow other than design maximum (reduced flow rates for variable volume systems) on the HVAC system's ability to remove particles and infectious aerosols

The following are issues beyond this guidance that it believes ASHRAE should address:

- Rather than "ventilation air", ETF guidance should standardize on a term such as "equivalent outdoor air" or "non-infectious air" along with a clear definition and explanation of that term (equivalent outdoor air used throughout this document)
- Support research to determine potential for airborne transmission of pathogens via different HVAC systems and configurations (central recirculating systems, classroom style units, single-zone rooftop units, etc.)
- Support research to further understand the impact of space relative humidity on potential for transmission of infectious aerosols
- Equivalent outdoor air target values (ACHe or CFM/SF above Code) need to be defined so building operators, owners, designers, TAB, CxP have objectives to reference
- Archive airborne pandemic lessons in a special publication
- ASHRAE Understand the value and impact on IEQ of proper existing building commissioning, and Testing, Adjust, Balance (TAB) efforts
- Develop method of test for air cleaning devices similar to 185 for UV
- Provide guidance and teaching the value of Health, Safety, and Welfare (HSW) as compared with energy impact

ASHRAE ETF – School Team Transition Report

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Team Members

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Julia Keen – Kansas State University
Keith Hammelman – Cannon Design
Kyle Hasenkox – Rocky Point Engineering
Raj Kapoor – Star Consultants Inc.
Raj Setty – Setty and Associates International

Team-Generated Guidance

This team has developed the following text, graphics, and tools that ASHRAE standing and technical committees may wish to consider when developing more durable, long-term standards and guidance:

- **Schools and Universities guidance main page**. (https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-reopening-schools-and-universities-c19-guidance.pdf)
- **One-page guidance document for Reopening Schools**. (https://www.ashrae.org/file%20library/technical%20resources/covid-19/guidance-for-the-re-opening-of-schools.pdf)
- **Frequently asked questions and answers for re-opening or shuttering buildings**

Other Guidance or Documents Developed with Support from Team

This team has developed the following text, graphics, and tools that ASHRAE standing and technical committees may wish to consider when developing more durable, long-term standards and guidance:

- **Core Recommendations for Reducing Airborne Infectious Aerosol Exposure**. (https://www.ashrae.org/file%20library/technical%20resources/covid-19/core-recommendations-for-reducing-airborne-infectious-aerosol-exposure.pdf)
- **In-Room Air Cleaner Guidance for Reducing COVID19 in Air in Your Space/Room**. (https://www.ashrae.org/file%20library/technical%20resources/covid-19/core-recommendations-for-reducing-airborne-infectious-aerosol-exposure.pdf)
- **How Schools Implemented Air Quality Measures to Protect Occupants from COVID-19**. (https://www.ashrae.org/file%20library/technical%20resources/covid-19/preparation-in-the-pandemic_iaq-in-schools_final2.pdf)
- **Managing Air Quality During the Pandemic: How K-12 Schools Addressed Air Quality in the Second Year of COVID-19**. (https://www.ashrae.org/file%20library/technical%20resources/covid-19/managing_air_quality_during_the_pandemic.pdf)

Section 1 - Lessons Learned

1. Reference Documents

ASHRAE standards, handbook chapters or special publications that team members found helpful for advising the public and developing residential COVID guidance.
The following is a listing of ASHRAE documents and non-ASHRAE documents that were used in building the guidance of this team. There are notes as to the importance of these documents to the guidance.

The following ASHRAE documents were used to help build the guidance documents:

- ASHRAE Standard 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
  - Impact of filter ratings and droplet nuclei capture efficiency.
- ASHRAE Standard 55
- ASHRAE Standard 62.1 – Ventilation for Acceptable Indoor Air Quality
  - Table 6-4 – for room air distribution effectiveness
  - For Code minimum OA requirements using the standard's prescriptive tables
- ASHRAE Standard 90.1
- ASHRAE Standard 111-2008 (RA 2017) - Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation and Air-Conditioning Systems
  - For evaluation of existing systems and the importance of proper TAB
- ASHRAE Standard 170
- ASHRAE Standard 180-2018: Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems
  - Impact of how systems can be maintained, or not, by facilities to improve their performance before the next pandemic
  - Developing checklists for the inspection of existing HVAC systems with a focus toward their ability to provide adequate filtration, ventilation, and, if necessary, air cleaning, with respect to mitigating the spread of infectious aerosols and particulates.
- ASHRAE Standard 188-2018: Legionellosis: Risk Management for Building Water Systems
  - Water quality impact of shuttering a building and re-opening
- ASHRAE Guideline 11-2018 – Filed Testing of HVAC Control Components
  - Proper check for existing systems operation and documenting control system and BAS capabilities for both on-site and remote monitoring of system function and performance.

- ASHRAE Guideline 36-2018 - High-Performance Sequences of Operation for HVAC Systems
  - Methods of control for systems that could be adopted to reduce energy during a pandemic
- 2019 ASHRAE Handbook—APPLICATIONS - Chapter 62 - Ultraviolet air and surface treatment
  - UV guidance for inactivating viruses and bacteria
- 2020 ASHRAE Handbook – HVAC Systems and Equipment – Chapter 26 – Air-to-Air Energy Recovery Equipment
  - Understanding of energy recovery wheels and thermal plates potential impact on air quality
- 2016 ASHRAE Handbook – HVAC Systems and Equipment – Chapter 17 – Ultraviolet Lamp Systems
  - UV guidance for inactivating viruses and bacteria
- ASHRAE RP-1088 titled Coordinate and Analyze Interlaboratory Testing of Filters under ASHRAE Standard 52.2 to Determine the Adequacy of the Apparatus Qualification Tests dated May 12, 2005, completed by RTI International
  - Impact of filter ratings and the capture droplet nuclei efficiency.
- ETF Building Readiness Guide
- ETF Filtration and Disinfection Guidance
- ETF Transportation Guidance
- ETF Laboratory Guidance
- ETF Exhaust Air Reentrainment Guide
- ETF Commercial Building Guide
- ETF Practical Guidance for Epidemic Operations of Energy Recovery Ventilation Systems
  - Authored by TC 5-5 (Air-to-Air Energy Recovery) and Building Readiness Team
- ASHRAE Position Document on Infectious Aerosols
- ASHRAE Position Document on Filtration and Air Cleaning
- ASHRAE Journal article: Ultraviolet Germicidal Irradiation - Current Best Practices (2008, Martin et al)
  - UV guidance for inactivating virus and bacteria

The following items are non-ASHRAE Publications that were used in the development of this document:

- Kowalski, W.J., Bahnfleth, W.P., 2002. “MERV Filter Models for Aerobiological Applications.” Air Media.
  - Relative performance of filters with different MERV ratings
- Tang, J., W. Bahnfleth, P. Bluyssen, et al. 2021. “Dismantling myths on the airborne transmission of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2).” J Hosp Infect. 110:89 – 96. https://doi.org/10.1016/j.jhin.2020.12.022
  - UV guidance for inactivating virus and bacteria
- Impact of filter ratings and droplet nuclei capture efficiency. Lindsley, W, F. Blachere, K. Davis, T. Pearce, et al. 2010. “Distribution of airborne infuenza virus and respiratory syncytial virus in an urgent care medical clinic.” Clin Infect Dis. 50(5):693 – 698.
  - UV guidance for inactivating virus and bacteria
  - Impact of filter ratings and droplet nuclei capture efficiency.
- Blachere, F., W. Lindsley, T. Pearce, S. Anderson, et al. 2009. “Measurement of airborne infuenza virus in a hospital emergency department.” Clin Infect Dis. 48(4):438 – 440.
  - UV guidance for inactivating virus and bacteria
  - Impact of filter ratings and droplet nuclei capture efficiency.
- Lindsley, W., F. Blachere, R. Thewlis, A. Vishnu, et al. 2010. “Measurements of airborne infuenza virus in aerosol particles from human coughs.” PLoS One 5(11): e15100.
  - UV guidance for inactivating virus and bacteria
  - Impact of filter ratings and droplet nuclei capture efficiency.
- Yang, W., S. Elankumaran, L. Marr. 2012. “Relationship between Humidity and Influenza A Viability in Droplets and Implications for Influenza’s Seasonality.” PLoS One 7(10): e46789.
  - Potential relationships between ambient humidity and viability of Influenza A
  - Filter Impact of filter ratings and droplet nuclei capture efficiency.
- Yang, W., S. Elankumaran, L. Marr. 2011. “Concentrations and size distributions of airborne infuenza A viruses measured indoors at a health centre, a day-care centre and on aeroplanes.” J R Soc Interface 8(61):1176 – 1184.
  - UV guidance for inactivating virus and bacteria
  - Filter Impact of filter ratings and droplet nuclei capture efficiency.

- Yang, W., L. Marr. 2011. “Dynamics of Airborne Influenza A Viruses Indoors and Dependence on Humidity.” PLoS One 6(6): e21481.
  - Potential impacts of relative humidity on airborne transmission of Influenza A
- Noti, J., W. Lindsley, F. Blachere, G. Cao, et al. 2012. “Detection of infectious infuenza virus in cough aerosols generated in a simulated patient examination room.” Clin Infect Dis. 54(11):1569 – 1577.
  - UV guidance for inactivating virus and bacteria
  - Impact of filter ratings and droplet nuclei capture efficiency.
- Azimi, P., B. Stephens. 2013. “HVAC filtration for controlling infectious airborne disease transmission in indoor environments: Predicting risk reductions and operational costs.” Building and Environment 70(Dec.):150 –160. https://doi.org/10.1016/j.buildenv.2013.08.025
  - UV guidance for inactivating virus and bacteria
  - Impact of filter ratings and droplet nuclei capture efficiency.
- AHAM. 2015. “ANSI/AHAM AC-1-2015, Method for Measuring Performance of Portable Household Electric Room Air Cleaners.” Association of Household Appliance Manufacturers.
  - In room air cleaner performance
- NIOSH Guidelines – 2009
  - Hierarchy of controls
- American Water Works Association (AWWA) - Shutoffs and Return to Service Guidance (https://www.awwa.org/Resources-Tools/Resource-Topics/Coronavirus#10681543-shutoffs-and-return-to-service-guidance)
  - Water quality for shuttering and re-opening buildings
- US Environmental Protection Agency - Information on Maintaining or Restoring Water Quality in Buildings with Low or No Use (https://www.epa.gov/coronavirus/information-maintaining-or-restoring-water-quality-buildings-low-or-no-use)
  - Water quality for shuttering and re-opening buildings

2. Open Issues

These are the issues that remain unaddressed by COVID-19 guidance as of November 2021.

The following are items that this team found to be unaddressed by our most recent guidance:

- **Target Ventilation or Equivalent Outdoor Air quantity required during occupancy for reduced risk during airborne infection emergencies**. We lack

quantitative values that would allow the industry to understand how to evaluate and upgrade their systems to achieve these targets.

Recommendation: Consider forming an SPC for "Disaster" IAQ to develop guidance for temporary targets or operating conditions for various disaster scenarios (flood, hurricanes, wildfires, infectious diseases, etc.). Separately work with SSPC 62.1 to incorporate recommended or required strategies to demonstrate "acceptable indoor air quality" through monitoring of space conditions, including potential factors such as temperature, humidity, carbon dioxide, particulate matter, volatile organic compounds, etc. Also request review of IAQP with respect to pandemic operation from SSPC 62.1.

- **Design guidance on the impact of room air distribution to reduce the direct transmission of infectious aerosols, considering different space types typically found in schools and universities**. It became clear that during this pandemic how air moved through the space impacted who would become infected. Also, our assumptions in most engineering tools and practices are based on "well mixed" air within spaces. It is also clear that air distribution in many spaces is not well mixed, and it appears very likely that some air distribution strategies will provide airborne pathogen transmission mitigation benefits when compared with other systems. It is also clear that space types typically found in schools and universities have different operating characteristics than many other commercial buildings, with higher occupant densities, different activity types and levels, and more potential for exposure due to occupant mixing in transient spaces. We need to again sponsor good research on the correction factors that should be used to correct for actual, in place air distribution systems in buildings and to provide recommendations for system configurations that can help to mitigate transmission of airborne pathogens.

  Recommendation: Have TC 5.3 – Room Air Distribution and/or MTG – Air Change Rate and/or TC-4.10 – Indoor Environmental Modeling - work on guidance for air distribution impact on risk of infection that can be implemented in designs to avoid issues in the next pandemic.

- **Impact of airflow other than design maximum (reduced flow rates for variable volume systems) on the HVAC system's ability to remove particles and infectious aerosols.** The guidance talks about the use of airflow, but it is obvious that the actual airflow versus design impacts the system's ability to mitigate transmission. It appears necessary to provide guidance for system operational targets across the operating range of dynamic systems to ensure guidance extends beyond a single operating condition to avoid situations where .

  Recommendation: Have TC 5.3 – Room Air Distribution and/or MTG – Air Change Rate and/or TC-4.10 – Indoor Environmental Modeling – work on guidance to discuss this issue.

3. Information for other ASHRAE Groups

What risk reduction guidance generated by this team for COVID-19 should be reviewed by other ASHRAE bodies to see if they believe it should be included in their handbook chapters, guidelines, or standards.

This is organized by ASHRAE committee or group that could potentially evaluate the materials for them to include. The applicable page of the documentation is noted as "# to ## of 45" for the Schools and Universities Guide to indicate the page of interest for that ASHRAE group.

TC 1.4 – Control Theory and Application

- Pages 6, 9, and 19 through 23 of 45: References to sequences or suggested operating conditions for pandemic mode operating conditions.

TC 1.12 – Moisture Management in Buildings

- Pages 18, 20, and 22 of 45: Consider impact of Increasing Space Relative Humidity during heating season to help reduce SARS-CoV-2/COVID-19 Transmission – this guide, in review for publication, covers the evaluation of increasing RH and the impact on the existing building envelope.

TC 2.4 - Particulate Air Contaminants and Particulate Contaminant Removal Equipment

- Pages 24 to 34 of 45: Considerations associated with upgrading filters in HVAC systems.

TC 2.9 – Ultraviolet Air and Surface Treatment

- Pages 19, 20, and 43 of 45: Review references to ultraviolet germicidal irradiation/UV-C to determine if additional guidance is necessary or appropriate, related specifically to typical school and university space types.

TC 2.10 – Resilience and Security

- Entire document should be reviewed to see how it fits their scope.

TC 4.3 – Ventilation Requirements and Infiltration

- Page 18 of 45: Review recommendations for ventilation on Designer Guidelines section.

TC 4.4 Building Materials and Building Envelope Performance

- Pages 18, 20, and 22 of 45: Consider impact of Increasing Space Relative Humidity during heating season to help reduce SARS-CoV-2/COVID-19 Transmission – specifically consider increased potential for condensation in building envelope.

TC 5.3 – Room Air Distribution

- Pages 19, 20, and 42 of 45: Review further whether well-mixed space is best approach to reducing transmission of airborne pathogens and provide specific consideration for typical school and university space types.

TC 7.3 – Operation, Maintenance and Cost Management

- Pages 7 to 16 of 45: Discusses the steps associated with determining building readiness for operation and steps to be taken during pandemic operation (some are similar to normal operation).

TC 9.7 – Educational Facilities

- Entire document should be reviewed and incorporated into handbook chapter or other documents as appropriate. This group is expected to be the primary party responsible for carrying information forward.

SPC 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

- Pages 24 to 34 of 45: Considerations associated with upgrading filters in HVAC systems.
- Page 25 of 45: General information on filters. Need to expand MERV-A discussion.

SSPC 62.1 – Ventilation for Acceptable Indoor Air Quality

- Page 18 of 45: Review recommendations for ventilation on Designer Guidelines section. Specific consideration to be given to sensor recommendations.
- Pages 24 to 34 of 45: Review considerations associated with upgrading filters in HVAC systems and consider providing recommendations for adjusted baseline filtration requirements if appropriate.

SPC 160-2016 -- Criteria for Moisture-Control Design Analysis in Buildings

- Pages 18, 20, and 22 of 45: Consider impact of Increasing Space Relative Humidity during heating season to help reduce SARS-CoV-2/COVID-19 Transmission – specifically consider increased potential for condensation in building envelope.

GPC 36-2021 - High-Performance Sequences of Operation for HVAC Systems

- Pages 6, 9, and 19 through 23 of 45: References to sequences or suggested operating conditions for pandemic mode operating conditions.

MTG.ACR – Air Change Rate

- Pages 19, 20, and 42 of 45: Consider whether spaces such as classrooms or similar should be included in the scope of the MTG. If determined to be appropriate, review further whether well-mixed space is best approach to reducing transmission of airborne pathogens and what impact this has on recommended air change rates.

MTG.HWBE – Health and Wellness in the Built Environment

- Page 18 of 45: Review temperature and humidity design criteria to verify ranges are appropriate.
- Page 18 of 45: Review recommendations for ventilation on Designer Guidelines section. Specific consideration to be given to sensor recommendations.
- Pages 19, 20, and 42 of 45: Review further whether well-mixed space is best approach to reducing transmission of airborne pathogens.
- Pages 24 to 34 of 45: Review considerations associated with upgrading filters in HVAC systems and consider providing recommendations for adjusted baseline filtration requirements if appropriate.

4. Issues Beyond this Guidance

Issues outside this team's assigned responsibilities that affect the effectiveness of ASHRAE's pandemic response.

To improve epidemic response, the ASHRAE Board of Directors may wish to consider these observations and suggestions:

- **Rather than "ventilation air", ETF guidance should standardize on a term such as "equivalent outdoor air" or "non-infectious air" along with a clear definition and explanation of that term.** There appears to be widespread confusion about the combination of the impact of air cleaning (fitters, UV, etc.) on recirculated air in addition to outdoor air to dilute and remove airborne pathogens. We believe that a universal and publicly comprehensible definition and explanation is important, but beyond the scope of our team's responsibilities.

  Recommendation: The ETF should consider using the term "equivalent outdoor air," "non-infectious air," or similar term. We suggest that a universal definition (applicable only to COVID-19 guidance) could be as provided in the Building Readiness Guide with the applicable Equivalent Outdoor Air Calculator Tool.

- **Support research to determine potential for airborne transmission of pathogens via different HVAC systems and configurations (central recirculating systems, classroom style units, single-zone rooftop units, etc.).** Based on several published studies, air distribution, ventilation, and filtration can have significant impacts on transmission of airborne pathogens. Most ETF guidance was developed with a focus well-mixed distribution and removal of pathogens from airstreams using MERV 13 or better filtration. Some air distribution strategies are likely better than others at mitigating risk in occupied spaces (likely dependent on space type and function) and the impact of filtration may also be dependent on space type (it may be more impactful for local recirculating systems to have improved filter efficiency than large central recirculating systems due to the potential for dilution).

  Recommendation: Support research to consider the impacts of different HVAC system types and configurations on transmission of airborne pathogens.

- **Support research to further understand the impact of space relative humidity on potential for transmission of infectious aerosols.** Several studies indicate that a range of relative humidity of 40 to 60 percent can help to mitigate transmission of airborne pathogens (best studies appear to be related to Influenza A). That said, some studies appear to indicate that relative humidity control may not have a significant impact when combined with other strategies (ventilation, filtration, etc.). Increasing relative humidity during the heating season in cold climates can create significant potential for condensation and moisture collection on or in the building envelope.

Recommendation: Support research that both focuses on the potential for mitigation of transmission of SARS-CoV-2/COVID-19 based on space relative humidity, considering other factors such as ventilation or filtration, and also considering the potential for adverse effects associated with condensation in the building envelope.

- **Equivalent outdoor air target values (ACHe or CFM/SF above Code) need to be defined so building operators, owners, designers, TAB, CxP have the appropriate goal for systems performance.** Public and professional expectations remain that ASHRAE should determine how much equivalent outdoor air will "keep people safer".

  The ETF's scientific team made extensive assessments of available outbreak studies and developed a complex but potentially credible methodology for recommending ventilation rates. Unfortunately, the number of assumptions and their uncertainty does not allow establishment of air flow rates that are physically possible and economically practical.

  Recommendation: Build a tool to utilize the scientific application teams efforts so that people can create their own target with the variables to be selected by the user. This tool and the goals are limiting the impact of the ETF on how systems should be modified for each situation.

- **Archive airborne pandemic lessons in a special publication.** To speed and improve future pandemic response by the worldwide HVAC community, a new special publication is probably the logical place to archive ASHRAE's airborne infection guidance. We consider a special publication to be a better option than a handbook chapter for two reasons: information about pandemics is not generally useful at other times, and a special publication can record the specifics of this and similar pandemics for reference as an historical event, rather than attempting to generalize guidance that may or may not be useful for future pandemics. Development of this special publication is probably best led by a new MTG that is comprised of the following: Environmental Health Committee, SPC 55.2, 62.1, 62.2, 185 and 300 and TCs 6.6, 4.3, 5.4, 7.9, 7.3, 7.7, and 7.8.

  Recommendation: The MTG should create an ASHRAE encompassing new special publication that focuses on the lessons learned about risk reduction by providing specific examples of documented events during recent airborne pandemics, e.g.: SARS-CoV-1, MERS and SARS-CoV-2 (and sub-variants). The ETF documents, referenced documents, and the transition reports would provide a lot of source material.

- **ASHRAE Understand the value and impact on IEQ of proper existing building commissioning, and Testing, Adjust, Balance (TAB) efforts.** Existing systems fall out of calibration and control over time impacting energy and IEQ. In addition, existing buildings may lack the IAQ measuring components that are being recommended due to this pandemic.

Recommendation: ASHRAE stress the impact of the Cx and TAB process on more than energy. Many studies have evaluated the impact of these items on energy but rarely is IEQ the focus of the study and their impact on improved IEQ. Fund research to evaluate the impact of existing building commissioning and proper TAB on the built environment IEQ.

- **Develop method of test for air cleaning devices similar to 185 for UV.** Several air cleaning technologies have been marketed and implemented frequently as a mitigation tool for preventing the transmission of airborne pathogens. While there have been many claims regarding the efficacy of these systems, there are not currently standards or third-party tests to independently validate efficacy of these systems.

  Recommendation: ASHRAE needs solid research and independent third-party evaluations of all new and existing air cleaning technologies and method of test standards to rapidly test any emerging technologies and new disaster scenarios present themselves in the future.

- **Provide guidance and teaching the value of Health, Safety, and Welfare (HSW) as compared with energy impact.** While energy efficiency is important, we should spend some time educating the public on the importance of HVAC systems on the health, safety, and welfare (HSW) of building occupants and that systems should provide for HSW first and be as efficient as possible while satisfying the basic HSW requirements.

  Recommendation:

  Have the Environmental Health Committee work with other ASHRAE Technical Groups to develop training on the impact of HSW and energy. This could be applicable to the common systems found in buildings and the optimization measures people are using to reduce energy.

Section 2 – List of Team-Generated Guidance

Information included at the front of the document so people reading this report are aware of the documents being referenced in Section 1 recommendations.

Section 3 – Technical References

See Sections 1.1 for the listing of references used by this team's guidance.

ASHRAE ETF – Transportation Team Transition Report
April 8, 2022

Executive Summary

This report is intended to help improve the Society's response to the life-safety threats presented by the COVID-19 pandemic. It can also assist ASHRAE technical committees as they seek to improve ASHRAE standards and guidance with respect to indoor air quality (IAQ) and to reducing risks of indoor transmission of airborne pathogens and infectious aerosols.

The report documents the collected experiences and recommendations of the transportation team of ASHRAE's COVID-19 Epidemic Task Force. The team focused on the development of guidance to be published on the ASHRAE website. The team decided early on in this effort to exclude automobiles (due to the small number of passengers served at one time) and cruise ships (due to its recreational nature) from consideration and focus on modes of transportation more likely to transport larger numbers of people and be needed to transport essential workers, particularly in areas of high population density. The team divided the guidance into categories based on the mode and the involvement of people, including both transit cabins and the associated facilities.

Team Members

Jason W. DeGraw, Oak Ridge National Laboratory
Augusto San Cristobal, Bronswerk Marine
Byron Jones Kansas State University
Donald LeBlanc, National Research Council Canada
Haven Cassidy, Denver International Airport
Jim Bushnell, HVAC Consulting Services

Section 1 - Lessons Learned

As briefly as possible, please answer these four questions based on the observations and experience of the team and its members with respect to the COVID-19 pandemic and ASHRAE's response.

1. *What specific paragraphs—**if any**—of any existing ASHRAE standard or volume of the ASHRAE Handbook were particularly helpful or counterproductive in guiding the efforts of HVAC and building science professionals to reduce risks of COVID-19 transmission?*

   The most applicable standard unique to the transportation team is ASHRAE Standard 161-2018, Air Quality within Commercial Aircraft, and specifically those parts of that standard related to ventilation (primarily section 6). Unfortunately, the only ASHRAE Standard that was directly helpful was Standard 170

   There is significant overlap between the guidance needed for transportation and other guidance offered by the task force, including

   - Commercial Buildings: Many transport-related facilities would be considered commercial buildings, so the guidance and helpful standards there apply here
   - Filtration/Disinfection: Both filtration and disinfection play a crucial role in the transportation space, so the guidance and helpful standards there apply here

   Other useful documents that are not a ASHRAE standard or volume of the handbook include:

1. ASHRAE Position Document on Infectious Aerosols (2020 revision)
2. CDC: "Use and Care of Masks" https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/about-face-coverings.html
3. Alberta Health Services: "COVID-19 Public Health Recommendations for Hotels, Hostels, and Inns" https://www.albertahealthservices.ca/assets/info/ppih/if-ppih-covid-19-environmental-guidance-for-hotels-kbk.pdf
4. WHO: "Operational considerations for COVID-19 management in the accommodation sector" https://apps.who.int/iris/bitstream/handle/10665/331638/WHO-2019-nCoV-Hotels-2020.1-eng.pdf
5. WHO: "Management of ill travellers at points of entry – international airports, ports and ground crossings – in the context of the COVID-19 outbreak" https://apps.who.int/iris/bitstream/handle/10665/331003/WHO-2019-nCoV-POEmgmt-2020.1-eng.pdf
6. WHO: "Coronavirus disease (COVID-19) travel advice" https://www.who.int/emergencies/diseases/novel-coronavirus-2019/travel-advice

2. *What issues—**if any**—remain unaddressed by the most recent ASHRAE COVID-19 risk reduction guidance generated by the team?* Please state the issue clearly in a single sentence and provide the reason(s) that the issue should be resolved by others to reduce risks of airborne infection in the future. Keep in mind that funding sometimes allows or prevents such volunteer efforts. When the team is aware of potential funding sources to support volunteer deliberation and analysis, please note the names and contact information for specific personnel at the organizations that may be able to provide such support.

   The transportation team is strongly of the belief that many of the unresolved areas in the transportation guidance, and indeed the overall ASHRAE ETF guidance, are related to a lack of knowledge of the generation rate of infectious material and the dose required for infection. The lack of knowledge around these two crucial parameters prevents any true outcomes-based risk assessment. While Wells-Riley quanta-based analysis has gained traction as way forward, but even so ASHRAE needs to be working to help facilitate better risk assessment approaches. The recent announcements from the White House on the National COVID-19 Preparedness Plan and related efforts indicate support from the U.S. government for improved IAQ, and ASHRAE should be advocating strongly in support of these efforts.

3. *Which risk reduction guidance generated by the team for COVID-19—**if any**—might also be appropriate for inclusion in existing or new ASHRAE handbook chapter or standards?* (Please provide the specific wording of the guidance, plus the reason(s) why and where it should be included in persistent ASHRAE guidance. Be aware that once published, ASHRAE guidance is sometimes unquestioned and becomes republished with little or no review for decades, during which there may be little or no risk of a pandemic.)

   There are two obvious places for pieces of the guidance to be included in persistent ASHRAE guidance:

   1. The sections of the guidance related to airplane cabins should be considered for inclusion in Standard 161. Section 8.9 of the standard deals with bacteria and viruses is limited in scope

and could be expanded to better address pandemic (and potentially endemic) disease spread.
2. The sections of the guidance related to facilities should be considered for addition to the "HVAC Security" handbook chapter.

Unfortunately, there is a dearth of guidance related to control of infectious aerosols in transit cabins other than those in passenger aircraft.

4. *Other **pandemic-related** issues—**if any**—outside the direct scope of this team's responsibilities that merit discussion or resolution by the overall ETF to help the Board of Directors fulfill ASHRAE's vision: A healthy and sustainable built environment for all.*

As noted above, there is a lack of ASHRAE guidelines or standards that apply to transit cabins beyond those in passenger aircraft. It is hoped that this deficiency will be addressed in the future and that the lessons of the pandemic will not be lost. Generation of new guidelines or standards in this area would likely need to come from a few technical committees within ASHRAE that already produce ventilation related guidelines and standards, so it is likely that other parts of ASHRAE may need to engage to sustain the effort needed to produce and maintain guidance for other transit cabins.

Section 2 – Team-Generated Guidance

To assist transition of the maintenance of COVID-19 guidance to technical committees, please list all guidance documents developed by this team and the issue date of the final version. Include the final versions approved and published by ASHRAE in the Appendix.

Transportation Guidance at https://www.ashrae.org/technical-resources/transportation

Section 3 – Transition Plan

Please list which entities in ASHRAE (Technical Committees, Standing Committees, Standard and Guideline Committees, etc.) will take over the work of the team and briefly summarize what steps have been taken to initiate the transfer of responsibility.

Transfer overall responsibility for the guidance to TC9.3 Transportation Air Conditioning. Most of the team is involved with this technical committee and the TC chair is on the team. As the lead cognizant committee for Standard 161, this is the logical place for the determination of the persistence of the guidance, whether that is inclusion in the standard or in other locations.

Some portions of the guidance, particularly those related to facilities, may be of interest to TC2.10 for inclusion in the output of that committee

Discussions with these two TCs will be initiated.

Appendix 1 – Team-Generated Guidance

- Transportation (11/20/2020) - www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-transportation-c19-guidance.pdf
- Transportation FAQ - www.ashrae.org/technical-resources/transportation-faq
- Practical Guidance for Vaccine Refrigerated Transportation and Storage Abstract - www.ashrae.org/file%20library/technical%20resources/covid-19/practical-guidance-for-vaccine-refrigerated-transportation-and-storage-abstract.pdf

Appendix 2 - Technical References

Please provide key peer-reviewed bibliographic references (including DOI numbers) that the team believes may be useful to future ASHRAE efforts to help reduce risks from airborne transmission. For each reference, please also include one or two sentences explaining why and how the reference may be useful.

ASHRAE ETF
Laboratory Team Report
March 25, 2022

Executive Summary

This report summarizes the findings of the Laboratory subcommittee of the ASHRAE Epidemic Task Force (ETF), as reported in their latest guidance document, dated 16 September 2021. Furthermore, this report provides a transition plan for the ownership of this information to the ASHRAE Technical Committee 9.10 – Laboratory Ventilation.

Lessons Learned

Initially, the laboratory environment was considered to be low risk for aerosol transmission of the SARS-CoV-2 virus because these facilities are already designed with the safety of occupants as a key performance indictor. Typically, laboratory ventilation systems are designed with high air exchange rates with 100% of the air exhausted to the atmosphere (i.e., no recirculation of the exhaust back into the supply air system). Furthermore, the exhaust systems are designed to handle highly toxic and odorous material and to minimize the re-entrainment of contaminated air back into nearby air intakes or other areas of potential public exposure.

In ASHRAE's initial position document on Infectious Aerosols (April 14, 2020) it lists several control strategies that could negatively impact the ventilation effectiveness in the lab, reduce the containment of fume hoods, and/or adversely affect the science which is taking part within the laboratory. Concerns included the recommendation of adding upper-room UVGI, adding local exhaust ventilation for source control, employing portable, free-standing HEPA filters, constructing floor to ceiling partitions and disable demand-controlled ventilation.

In response to these recommendations, the Laboratory subcommittee of the ETF was formed in May 2020. The objective of the committee was to create a guidance document that was specifically applicable to the unique ventilation requirements associated with laboratory environments that involve the use of toxic substances. While the guidance document addresses each of the concerns listed above, it also goes into several unique conditions in the laboratory that should be addressed, such as the use of chilled beams, space pressurization, and transfer air. It further discusses the recommendation for a risk assessment to evaluate the appropriate air flow requirements and provides guidance on the design of future laboratories to minimize cross contamination. To aid the facility management, the guidance document also includes a checklist for the building automation system and the ventilation system which can help identify any deficiencies with the current operations.

One specific item that came out of the committee was a challenge on the cascading of air flow. Typically, the air entering the laboratory is considered clean, it then picks up potential contaminants through the room, mainly across work benches, and then exhausts the contaminated air either through exhaust ducts, local exhaust vents (LEVs) or into the fume hood (which is considered to contain the most contaminated air within the laboratory). As such, many designers are implementing cascading air systems where fresh air is brought into the building's non-lab spaces and then transferred directly into the laboratory. This can reduce the size and number of air handlers, the amount of duct work in the building, and the overall energy consumption. This may work well as long as there are no contaminants in these non-lab spaces. During an airborne virus pandemic, this may not be a valid assumption. Even within the lab, the

transfer of air from across the room may place individuals in the lab at greater risk of infection, particularly those standing at the front of the fume hoods.

Technical References

In addition to ASHRAE, there are a number of organizations and government agencies that have developed guidance that is specifically related to minimizing the exposure to the SARS-CoV2/COVID 19 virus. Most of these guidance documents are available on-line and should be referenced on a regular basis for potential updates. Specific guidance documents identified by the task force include:

- ABSA- The Association for Biosafety and Biosecurity (https://absa.org/covid19toolbox/)
- CDC –U.S. Centers for Disease Control and Prevention (https://www.cdc.gov/coronavirus/2019-ncov/community/index.html)
- AIHA – American Industrial Hygiene Association (https://www.aiha.org/public-resources/consumer-resources/coronavirus_outbreak_resources)
- ANSI/ASSP - American National Standard Institute/American Society of Safety Professionals Standard Z9.5 Laboratory Ventilation (https://www.assp.org/resources/covid-19/latest-resources)
- EPA – Environmental Protection Agency (https://www.epa.gov/coronavirus)
- I2SL – International Institute for Sustainable Laboratories (https://www.i2sl.org)
- SLCan - Sustainable Labs Canada (https://www.slcan.ca/)
- CSHEMA – Campus Safety, Health, and Environmental Management association (https://www.cshema.org/covid-19)

Transition Plan

The information contained in the ETF Laboratory Guidance Document was developed using the best information that was available at that time regarding the potential spread of an airborne infectious virus, such as SARS-CoV2. A greater wealth of information and research will likely continue to be made available. Therefore, the ASHRAE Technical committee TC9.10 has agreed to maintain the ETF Laboratory Guidance Document and update it as applicable.

In addition to maintaining a current version of the ETF Laboratory Guidance Document, the TC is also responsible for maintaining a Laboratory Design Guide. It is anticipated that information from the ETF Laboratory Guidance Document will be included either in the appropriate chapter of this design guide, or as a stand-alone chapter in a future version of the guide. Adding the ETF Laboratory Guidance Document information to the Laboratory Design Guide provides a mechanism for keeping the knowledge base as current as possible while also providing a method of disseminating the information to the general public in a timely manner.

Appendix 1 – Team-Generated Guidance

- ASHRAE Epidemic Task Force Laboratory Subcommittee Guidance Document (9/16/2021) - www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-etf---lab-guidance.pdf
- Laboratory FAQs - https://www.ashrae.org/technical-resources/laboratory-systems-faq
- Laboratory One Page Guidance (2/8/2021) - www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-etf-laboratory-one-page-guidance.pdf

Introduction

This report is intended to help improve the Society's response to the life-safety threats presented by the COVID-19 pandemic. It can also assist ASHRAE technical committees as they improve ASHRAE guidance with respect to reducing risks of indoor transmission of airborne infectious agents.

The report documents the collected experiences and recommendations of the industrial team of ASHRAE's COVID-19 Epidemic Task Force. The team began work in February 2020, and met on a monthly basis through 2021. This report reflects the industrial team's perspectives and recommendations as of December 2021.

Industrial Team Members

John McKernan (Team Leader)
Erich Binder (Chair, TC 9.2)
Duncan Phyfe (ASHRAE TC 9.2)
Don Larsson (ASHRAE Member)
Matt Gaedtke (ASHRAE TC 9.2)
Kevin Marple (ASHRAE TC 9.2)
Deep Ghosh (ASHRAE TC 9.2)
Stephen Martin (ASHRAE ETF Filtration & Disinfection Team Lead, ASHRAE TC 2.9, SPC 185)
James Ridenhour (ASHRAE ETF)
Joel Foster (ASHRAE Member)
Graeme Magor (ASHRAE Member)
Jonathan Hale (Chair, ACGIH Industrial Ventilation Committee)
Jennifer Topmiller (Member, ACGIH Industrial Ventilation Committee)
Sergio Caporali (Member, ACGIH Industrial Ventilation Committee)
Neil Zimmerman (Member, ACGIH Industrial Ventilation Committee)
Rob Strode (AIHA Member)
Bill Mele (AIHA Member)
Monona Rossol (Consultant, ACGIH Industrial Ventilation Committee)

Section 1 - Lessons Learned

1. ASHRAE standards, handbook chapters or special publications that team members found helpful for advising the public and developing residential COVID guidance.

Few existing standards or publications proved useful to our team members during this pandemic, perhaps because the hierarchy of risk factors and therefore relevant risk reduction measures for COVID-19 were not fully understood until late 2020. Most ASHRAE guidance was developed in prior years, for purposes other than reducing risks of COVID-19.

Publications that were useful as minimum requirements:

- ASHRAE Standards 62.1 (2019) and 62.2
- 2019 ASHRAE Handbook— HVAC Applications - Chapter 15: Industrial Air Conditioning, Chapter 32: Ventilation of the Industrial Environment, and Chapter 58: Room Air Distribution
- 2020 revision of the ASHRAE Position Document on Infectious Aerosols

Additional informmation was referenced from the American Conference of Governmental Industrial Hygienists, Industrial Ventilation: A manual for recommended practice for design, 30th Ed.

Team recommendation: To be more responsive to pandemics and epidemics, ASHRAE senior leadership should consider directing standing committees to expand and update these documents and other relevant materials, based on lessons learned during the current pandemic.

2. Issues that remain unaddressed by industrial COVID-19 guidance as of December 2021.

Major issues that have been researched and discussed by the industrial team, but remain either unresolved or incomplete include:

- **Ceiling fan usage and mixing:** developing recommendations/non-recommendation for large ceiling fan use. There is discrepancy among members regarding proper use or non-use of air mixing fans mounted to ceilings. These are generally referred to in the industry as 'BAFs' and help de-stratify room air, leading to better overall room mixing. In times when there is not an airborne viral pandemic – room air mixing is desirable during 'extreme' months (hot/cold), as room air has the tendency to stratify during these time periods when indoor air temps differ greatly from outdoor air temperatures. Therefore, indoor air mixing to de-stratify air masses helps mitigate high air conditioning/heating costs. If a reasonable amount of outdoor/clean dilution air is available for the number of occupants in a large space, then there may be some reasoning to justify ceiling fan use to mix and dilute the room air. However, the lack of information on the number of infectious particles required for human transmission (quanta), the lack of data on inactivation time of the virus in typical indoor air environments (RH, UV exposure, etc.), and current data on transmissibility of the delta variant would all seem to preclude ceiling fan use. As knowledgeable consultants in the proper design and use of ventilation, we do know that exhaled air from room occupants tends to rise and mix near the ceiling, thus most room air returns are purposefully located near or in the ceiling. Using a fan to push air near the ceiling down toward room occupants, especially if we have some idea that the current variant of the virus is 'more' infectious than past variants, would seem unwarranted. There has been much discussion and strongly differing opinions surrounding this issue.

  Team recommendation: Working with the support of the Environmental Health Committee, indoor air and commercial building related committees should develop and publish ASHRAE guidance for appropriate use of ceiling/mixing fans.

- **Outdoor air and/or filtered air delivery rates:** Recommendations that include using 100% outdoor air, with no recirculation have left many HVAC users in work environments that are not appropriately heated or cooled per ASHRAE 62.1. Also, the control of RH is unmanaged for the most part due to an inability to control humidity when using multi-pass, closed HVAC systems in 'single pass' air handling mode (which they are not appropriately designed or sized for). This leaves HVAC professionals in a situation where we may have to recommend some percentage of recirculated air to attain room temperature comfort and some measure of RH control. However, filtered air is not 'parameterized' to give us a way to calculate how much can be recirculated if this filtered air is part of the makeup air stream for the HVAC system when we cannot operate in 100% outside air mode. We are uncertain how to manage this, given that MERV rated filters are

known to remove a percentage of particles in the viral range, but not all. Therefore, there is no guarantee of complete hazard removal. Some statistically designed means of calculating MERV filtered and recirculated air with outdoor air mixing is needed to ensure acceptable risk for building occupants, while maintaining indoor air parameters that meet ASHRAE 62.1 requirements. Portable HEPA air cleaners, UV disinfection and potentially other technologies may come into play, but developed guidance for industrial environments is needed.

- **Team recommendation:** Working with the support of the Environmental Health Committee, indoor air and commercial building related committees should develop and publish ASHRAE guidance for limiting risks of transmission of airborne pathogens in these buildings.
- **Energy usage with respect to increased outside air requirements:** The amount of energy needed to condition the outside air increases in climates where the outdoor ambient conditions vary from the inside environmental conditions required. There are different options for conditioning industrial facilities that may not parallel commercial facilities. Direct fired gas burners in makeup air units are an efficient way to heat outside air to prior to delivering it to the indoor space. Building pressurization, and low discharge temperature from the makeup air units also save energy in these applications. Industrial heat recovery usually does not include the use of energy wheels due to the harsh industrial requirements. Air to air plate heat exchangers, heat pipes, and run around coils are more applicable and serviceable in industrial applications. Low intensity gas fired infrared radiant heat is a very energy efficient way to heat specific inhabited areas in within an industrial facility. The combination of infrared heat and low temperature makeup air is referred to as an "Industrial Hybrid H & V System". It is usually not necessary to heat the uninhabited areas throughout the facility to the same temperature as the worker areas. The "Industrial Hybrid H & V System" can provide comfortable working conditions using infrared in specific areas, while providing sufficient ventilation air to the entire facility at a lower temperature. Cooling and dehumidification of industrial facilities will be energy intensive, but heat recovery and evaporative cooling may lower the total energy required.
- **Team recommendation:** Working with the Technical Committees associated with the technologies introduced above to educate the practitioners in industrial applications of direct fired makeup air units, low intensity gas fired infrared radiant and evaporative cooling to address industrial energy use with increased outside air. Research & tool development for the "handbook" that would provide online/off-line calculations to support decision making would also be welcomed.
- **Workplace layout, worker locations and complimentary ventilation design:** The workplace should be well designed, meeting the OSHA requirements of a safe and healthy workplace for all employees. The U.S. experience during the pandemic has shown that numerous workplaces do not meet this metric. Numerous administrative and engineering controls could be recommended and used to improve workplace conditions. These recommendations could come from ASHRAE TCs related to industrial, workplace, indoor air and environmental health.

- **Team recommendation:** Working with the support of the ACGIH, Environmental Health Committee, indoor air and commercial building related committees should develop, publish and/or update ASHRAE guidance on workplace process layout and ventilation to meet the needs of the identified processes to ensure the workplace is safe (similar to ACGIH Ventilation System (VS) plate designs). Research & tool development for the "handbook" that would provide online/off-line calculations to support decision making would also be welcomed.

3. Recommended New/Changed Industrial Guidance (with justification and wording)

See red in sections 2 and 4 for specific recommendations and justification for same.

4. Issues outside the industrial team's assigned responsibilities that affect the effectiveness of ASHRAE's pandemic response.

To improve pandemic response, the ASHRAE Board of Directors may wish to consider these observations and suggestions:

- **Rather than "ventilation air", ETF guidance should use the term "non-infectious air" along with a clear definition and explanation of that term.** Our team members believe that in the industrial space there is confusion about the combination of ventilation and filtered air that ASHRAE recommends to simultaneously dilute and remove airborne virus. A universal and publicly comprehensible definition and explanation is important, but beyond the scope of our team's responsibilities.
- **"Safe" non-infectious air flow rates are not practical to either define or implement.** Public and professional expectations remain that "somebody" (ASHRAE) should determine how much ventilation would be 'effective.' The ETF's scientific team made extensive assessments of available outbreak studies, and developed a complex but potentially credible methodology for recommending ventilation rates. Unfortunately, the number of assumptions and their uncertainty does not allow establishment of air flow rates that are physically possible and economically practical.
- **Team recommendation:** It would be best for the Society to clearly state that although increasing ventilation and filtration will reduce risks, there are many unknowns of the numbers and infective status of occupants for any amount of uninfected air to assure "safety." Focusing on vaccination, masking and reducing occupancy should be the primary means of reducing risks rather than relying on HVAC measures to compensate for the substantial risk of airborne infection when these primary means of risk reduction are not employed.
- **Archive airborne pandemic lessons in a special publication.** To speed and improve future pandemic response by the worldwide HVAC community, a new special publication is probably the logical place to archive ASHRAE's airborne infection guidance. We consider a special publication to be a better option than a handbook chapter for two reasons: information about pandemics is not generally useful at other times, and a special publication

can record the specifics of this and similar pandemics for reference as an historical event, rather than attempting to generalize guidance that may or may not be useful for future pandemics.

Section 2 – List of Team-Generated Guidance

The industrial team has developed a joint ASHRAE/American Conference of Governmental Industrial Hygienists (ACGIH) white paper regarding ventilation for industrial settings. In the future, standing and technical committees should consider developing more durable, long-term guidance. Available documents and videos include:

- Ventilation for Industrial Settings During the COVID-19 Pandemic: www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-acgih-covid-19-white-paper.pdf
- Frequently asked questions and answers for reopening and restarting commercial/industrial HVAC systems: www.ashrae.org/technical-resources/frequently-asked-questions-faq
- 3 presentations available through ACGIH and ASHRAE for technical users.

Section 3 – Transition Plan

See sections 1 and 2 for specific, near-term recommendations that transfer the suggestions of the industrial team to specific technical committees (such as TC 9.2).

More generally, we propose that on January 1st 2022 (or a later date as approved by the ETF, the industrial team intends to cease regular meetings and transfer responsibility for further adjustment of airborne epidemic guidance to the ASHRAE Industrial HVAC Committee (TC 9.2), ASHRAE filtration and disinfection committee (TC 2.9) and the Environmental Health Committee (EHC), along with the specific recommendations for further work as described in section 1.

Appendices

Appendix 1 – Team-Generated Guidance

- Ventilation for Industrial Settings During the COVID-19 Pandemic: www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-acgih-covid-19-white-paper.pdf
- Frequently asked questions and answers for reopening and restarting commercial/industrial HVAC systems: www.ashrae.org/technical-resources/frequently-asked-questions-faq

Appendix 2 – Technical References

Suggested references on the principal issues related to HVAC and COVID-19 are provided below. Not all of these studies are specifically industrial, but support the judgements and decisions that professionals and building owners have had to make during the current pandemic.

Team recommendations: Technical experts assigned by the ASHRAE ETF leadership should consider:

a. Reviewing these studies to determine if they merit long-term inclusion in the ETF technical references.

b. Adopting the criterion that no reference be included in ETF references that lacks a brief explanation of why the reference is included in the list.

c. Adopting (or adapting) the section titles below as an aid to navigation for current and future readers of ASHRAE's COVID-19 technical references.

Reference List:

1. American Conference of Governmental Industrial Hygienists: Industrial Ventilation: A Manual of Recommended Practice for Design. Cincinnati, OH: ACGIH (2019).
2. ANSI/ASHRAE: Standard 62.1-2019. Ventilation for Acceptable Indoor Air Quality (2019).
3. ASHRAE: Chapter 62 Ultraviolet Air and Surface Treatment. In ASHRAE Handbook: HVAC Applications, pp. 62.1–62.17 (2019).
4. ASHRAE: ASHRAE Position Document on Infectious Aerosols. Atlanta, GA: ASHRAE (2020). CDCa: Coronavirus (COVID-19). Retrieved from Centers for Disease Control and Prevention: www.cdc.gov/coronavirus/2019-nCoV/index.html July 20, 2020.
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ASHRAE ETF
Filtration & Disinfection Team Report
April 8, 2022

Introduction

This report is intended to help improve the Society's response to the life-safety threats presented by the COVID-19 pandemic. It can also assist ASHRAE technical committees as they improve ASHRAE guidance with respect to reducing risks of indoor transmission of airborne infectious agents.

The report documents the collected experiences and recommendations of the Filtration and Disinfection (F&D) Team of ASHRAE's COVID-19 Epidemic Task Force. The team began work in February 2020 and met frequently to establish early guidance. Once guidance was established, the team (or portions of the team) met on an as needed basis through the end of 2021. This report reflects F&D team's perspectives and recommendations as of December 2021.

Filtration and Disinfection Team Members

Stephen B. Martin, Jr., National Institute for Occupational Safety and Health (Team Leader)
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Edward Nardell, Harvard Medical School
Dean Saputa, UV Resources
Steven Welty, Green Clean Air

Section 1 - Lessons Learned

As briefly as possible, please answer these four questions based on the observations and experience of the team and its members with respect to the COVID-19 pandemic and ASHRAE's response.

1. ASHRAE standards, handbook chapters or special publications that team members found helpful for advising the public and developing COVID guidance for Filtration and Disinfection.

ASHRAE Standards

- ANSI/ASHRAE Standard 52.2-2017 -- Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
- ANSI/ASHRAE Standard 62.1-2019 -- Ventilation for Acceptable Indoor Air Quality
- ANSI/ASHRAE Standard 62.2-2019 -- Ventilation and Acceptable Indoor Air Quality in Residential Buildings
- ANSI/ASHRAE/ASHE Standard 170-2017 -- Ventilation of Health Care Facilities
- ANSI/ASHRAE Standard 185.1-2020 -- Method of Testing UV-C Lights for Use in Air-Handling Units or Air Ducts to Inactivate Airborne Microorganisms
- ANSI/ASHRAE Standard 185.2-2020 -- Method of Testing Ultraviolet Lamps for Use in HVAC&R Units or Air Ducts to Inactivate Microorganisms on Irradiated Surfaces

ASHRAE Handbook Chapters

- 2020 ASHRAE Handbook—HVAC Systems and Equipment: Chapter 17, Ultraviolet Lamp Systems
- 2020 ASHRAE Handbook—HVAC Systems and Equipment: Chapter 29, Air Cleaners for Particulate Contaminants
- 2019 ASHRAE Handbook—HVAC Applications: Chapter 62, Ultraviolet Air and Surface Treatment

ASHRAE Special Publications

- ASHRAE Environmental Health Committee (EHC) Emerging Issue Brief: Pandemic COVID-19 and Airborne Transmission (Approved April 17, 2020)
- ASHRAE Position Document on Infectious Aerosols (Approved April 14, 2020)
- ASHRAE Position Document on Filtration and Air Cleaning (Reaffirmed February 2, 2021)
- ASHRAE Environmental Health Committee (EHC) Emerging Issue Brief: Ozone and Indoor Chemistry (Approved January 2011)

Other Key References

- CDC Ventilation in Buildings webpage
- CDC Cleaning and Disinfecting Your Facility webpage
- CDC/NIOSH Environmental Control for Tuberculosis: Basic Upper-Room Ultraviolet Germicidal Irradiation Guidelines for Healthcare Settings
- EPA About List N: Disinfectants for Coronavirus (COVID-19) webpage
- EPA Guide to Air Cleaners in the Home

2. Issues that remain unaddressed by F&D COVID-19 guidance as of December 2021.

Major issues that have been researched and discussed by the F&D team, but remain either unresolved or incomplete include:

- Is air cleaning equivalent to a MERV-13 level appropriate in all settings to control SARS-CoV-2? Can it be lower in some settings? Does it need to be higher in others? How do we determine what is equivalent to MERV 13 when adding in-room units or additional outdoor air in lieu of better HVAC filtration?
- Does viable SARS-CoV-2 transmit through HVAC filters in concentrations that can cause infection? If so, what MERV-level is truly necessary to prevent it?
- Should pandemic recommendations be based on MERV-A filters instead of MERV filters to help ensure filtration efficiency throughout the life of the filters?
- What is the ASHRAE position on do-it-yourself (DIY) air cleaners? How does it relate DIY units to commercial units?
- What is truly understood about each emerging air-cleaning technology (bipolar ionization, photocatalytic oxidation, electronic air cleaners, 222 nm ultraviolet, etc.), many of which are called reactive air cleaners (RAC)? What questions still need to be answered in terms of efficacy and safety for each? What testing is necessary to determine an equivalent level of air cleaning for these devices?

- What is required for ASHRAE to consider emerging air-cleaning technologies as proven safe and effective, including acceptable levels for byproducts? Can those thresholds be clearly identified so manufacturers know what the organization expects?
- While ASHRAE currently supports the use of upper-room and in-duct 254 nm ultraviolet germicidal irradiation (UVGI), does it support the use of downlighting spaces with 222 nm UV, particularly given the recent increase to the ACGIH Threshold Limit Value for UV at this wavelength? Does ASHRAE support Direct Irradiation Below Exposure Limits (DIBEL) using ultraviolet devices?

3. Risk reduction guidance generated by the F&D team for COVID-19 that might be appropriate for inclusion in existing or new ASHRAE handbook chapter or standards

- TC 2.4 – Particulate Air Contaminants and Particulate Contaminant Removal Equipment: Information on SARS-CoV-2 and other infectious aerosols could be included in updates to 2020 ASHRAE Handbook—HVAC Systems and Equipment: Chapter 29, Air Cleaners for Particulate Contaminants and the new Handbook Chapter on In-Room Air Cleaners (no chapter number yet).
- TC 2.9 – Ultraviolet Air and Surface Treatment: Information on UV inactivation rate constants for SARS-CoV-2 and other infectious organisms that are spread through the air should be added during updates to 2020 ASHRAE Handbook—HVAC Systems and Equipment: Chapter 17, Ultraviolet Lamp Systems and/or 2019 ASHRAE Handbook—HVAC Applications: Chapter 62, Ultraviolet Air and Surface Treatment.

4. Issues outside the industrial team's assigned responsibilities that affect the effectiveness of ASHRAE's pandemic response.

To improve pandemic response, the ASHRAE Board of Directors may wish to consider these observations and suggestions:

- **Develop robust, distinct terminology for different types of "clean air." Use those well-defined terms consistently in ASHRAE documents and develop tools to help people understand how various air streams can be used to protect against infectious aerosols.** There is obvious confusion among the public when it comes to some of the terminology for air streams that are free of infectious aerosols and how they relate to one another. For instance, "outdoor air" is generally free from infectious aerosols and free from typical IAQ contaminants. Air passing through filters is free from infectious aerosols (or at least shows a significant reduction in concentration) but may still contain many typical IAQ contaminants. Mixed air streams are not straight forward to many. Air treated with emerging air cleaners is difficult to describe. Consumers and end users have a difficult time with these terms and how they ultimately relate to one another in an overall strategy to protect from infectious aerosols.

- **Non-infectious air flow rates (ACH or CFM/SF above code minimum) should be researched and defined so building owners and operators have protective targets.** These may need to be specific to occupancy types. These need to be explained in proper terms where they will make people within the spacer "safer," but they will not prevent all infectious disease transmission. The ETF's Scientific Team made extensive assessments of available outbreak studies and developed a complex but potentially credible methodology for recommending ventilation rates. Unfortunately, the number of assumptions and their uncertainty did not allow establishment of air flow rates that were physically possible and

economically practical at the time. As more research becomes available, improvements to the methodology are likely possible.

- **Conduct research and develop test methods for all types of portable, in-duct, and in-room air cleaning devices.** This could be done solely within ASHRAE or in conjunction with other testing agencies (e.g., AHAM for residential units). ASHRAE needs solid research and independent third-party evaluations of all existing and emerging air cleaning technologies, so statements can be made in support of or against devices that are based in scientific fact. Not having this information available for many of the emerging technologies was a significant limitation in ASHRAE's COVID-19 guidance.

- **Capture all ASHRAE ETF guidance for COVID-19 in an ASHRAE publication or online archive.** The guidance generated will be useful for any future pandemic or outbreak of infectious diseases spread through the air (with some notable exceptions). Having the existing guidance archived and readily available will allow rapid updating and prompt release of guidance applicable to future events.

Section 2 – List of Team-Generated Guidance

The F&D team developed the following guidance throughout their work:

- Filtration and Disinfection Slide Set (updated October 21, 2021): https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-filtration_disinfection-c19-guidance.pdf.
- Filtration and Disinfection Guidance Webpage (updated October 21, 2021): https://www.ashrae.org/technical-resources/filtration-disinfection.
- Filtration and Disinfection Frequently Asked Questions (7 total): https://www.ashrae.org/technical-resources/filtration-and-disinfection-faq.
- One Page Guidance Document, entitled In-Room Air Cleaner Guidance for Reducing COVID19 in Air in Your Space/Room (updated January 21, 2021): https://www.ashrae.org/file%20library/technical%20resources/covid-19/in-room-air-cleaner-guidance-for-reducing-covid-19-in-air-in-your-space-or-room.pdf.

- F&D Team directly answered over 135 questions from the public. This number does not count questions on filtration and disinfection answered directly by Bill Bahnfleth, Steve Hammerling, or other ASHRAE staff.

Section 3 – Transition Plan

It is anticipated that the F&D Team will cease regular meetings at a date approved by the ETF in the first half of 2022. At that time, the team intends to cease regular meetings and transfer responsibility of building upon the existing guidance to cognizant groups within ASHRAE. The final effort of the F&D team, prior to disbanding will be to:

- Complete one final update of the existing F&D guidance online (https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-filtration_disinfection-c19-guidance.pdf and https://www.ashrae.org/technical-resources/filtration-disinfection). At a minimum, the update will align CDC position statements within the guidance to current language from the agency.
- A brief FAQ outlining ASHRAE's position on do-it-yourself (DIY) air cleaners. Given the level of publicity for these DIY air cleaners, ASHRAE might be remiss not to address the issue. It is anticipated the FAQ will acknowledge that DIY air cleaners can work, but great care must be taken in their design, construction and operation. ASHRAE recommends the use of tested, commercially-available air cleaners over DIY units whenever possible.

Early in the pandemic, in addition to focusing on air cleaning, the F&D team provided timely guidance on chemical disinfectants, personal protective equipment, masks, etc. However, as sound guidance on these topics became available through WHO, CDC, EPA, the importance of F&D guidance in these areas was lessened. For much of the last 18 months, the primary focus of the F&D guidance has been air cleaning (including germicidal ultraviolet) and some surface disinfection (mainly cleaning HVAC components like window air conditioners, terminal units, etc.).

Air cleaning, particularly particle filtration and ultraviolet technologies, had home bases within ASHRAE prior to the COVID-19 pandemic. Many of the emerging technologies did not have suitable homes within the ASHRAE structure prior to the pandemic. New groups have been formed over the last two years to provide these technologies better representation. It is clearly important these technologies are welcomed under the overall ASHRAE umbrella so the Society is ultimately better prepared to provide scientifically-based guidance for/against the use of these emerging devices.

The recommended transition from the ETF F&D Team to the typical ASHRAE structure places responsibility for different portions of our work within the groups shown below. For most, this is a continuation of their expected roles while TG2.RAST is newly formed and, thus, newly fitting into the air cleaning coverage. These committees will be responsible for keeping up with changes in the industry and available equipment to be ready to address future issues. Specific examples of tasks these groups should consider are as follows:

- **TC 2.4 – Particulate Air Contaminants and Particulate Contaminant Removal Equipment**
  Information on SARS-CoV-2 and other infectious aerosols could be included in updates to 2020 ASHRAE Handbook—HVAC Systems and Equipment: Chapter 29, Air Cleaners for Particulate Contaminants
- **TC 2.9 – Ultraviolet Air and Surface Treatment**
  Information on UV inactivation rate constants for SARS-CoV-2 and other infectious organisms that are spread through the air should be added during updates to 2020 ASHRAE Handbook—HVAC Systems and Equipment: Chapter 17, Ultraviolet Lamp Systems and/or 2019 ASHRAE Handbook—HVAC Applications: Chapter 62, Ultraviolet Air and Surface Treatment. *Note: TC 2.9 does have a RAC-approved Work Statement in the queue to go out for bids with the aim to gather high-quality inactivation rate constant data from published literature for common pathogens spread through the air and on surfaces. SARS-CoV-2 and other human coronaviruses should be included in that work*.
- **TG2.RAST – Reactive Air and Surface Treatment**

This new TG was created during the COVID-19 pandemic to serve as the ASHRAE home for many of the emerging air cleaning technologies. Specifically, this group will represent technologies that use reactive oxygen species or ionization to clean the air. This group should work quickly to develop ASHRAE standards to test product efficacy against infectious aerosols (or their surrogates). TPS is currently under development for a chamber with side duct test method to cover devices that are either mounted in an HVAC duct but work in the room or one located in the room that require recirculating air.

- **GPC 37 – Guidelines for the Application of Upper-Air (Upper Room) Ultraviolet Germicidal (UV-C) Devices to Control the Transmission of Airborne Pathogens**
  A complete final draft of the Guideline document is expected in 2022. This guideline should be published as quickly as possible, as it will likely replace the NIOSH guidelines (Environmental Control for Tuberculosis) as the *de facto* U.S. standard (and many other countries) for upper-room ultraviolet germicidal systems. However, the current guideline document is only focused on classical 254 nm UV sources. Once published, the GPC 37 committee should immediately begin a revision (or perhaps a ne document) to include newer, developing UV technologies like UV light-emitting diodes and 222 nm krypton-chloride sources (commonly referred to as far UV). Design guidance for systems using these new sources will be critical for future pandemics.
- **SSPC 52.2 – Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size**
  The new bioaerosol test option in Standard 52.2 will be maintained. Educating the ASHRAE community about the existence of the test should be considered. The issue of drop-off in efficiency with use for charged media filters, currently seen as the issue of MERV vs MERV-A, should be addressed again.
- **SSPC 185 – Methods of Test to Inactivate Microorganisms in HVAC Systems with UV-C Lights**
  Since 2005, SSPC 185 has been the home for Standard 185.1 (originally published in 2015) and 185.2 (originally published in 2014). During the COVID-19 pandemic, the SSPC received approval to develop two new standards.
  - **Standard 185.1 (Subcommittee) – Method of Testing UV-C Lights for Use in Air-Handling Units or Air Ducts to Inactivate Airborne Microorganisms**
    Consideration should be given to including a viral surrogate in the standard, even if optional, to provide information on expected performance of in-duct devices for human coronaviruses, influenza, etc.
  - **Standard 185.2 (Subcommittee) – Method of Testing Ultraviolet Lamps for Use in HVAC&R Units or Air Ducts to Inactivate Microorganisms on Irradiated Surfaces**
    No changes to this standard are deemed necessary.
  - **Standard 185.3 (Subcommittee) – Method of Testing In-Room Devices and Systems for Microorganism Removal or Inactivation in a Chamber**
    Before the formation of TG2.RAST, this standard was conceived to test any air cleaning device used inside a room (not specific to UV devices) for removal efficiency against airborne microbiological particles. It is envisioned to be similar to the AHAM test for residential air cleaners that result in a CADR rating, except for commercial-sized devices. Work developing the standard is proceeding in earnest. The committee is encouraged to develop a robust test standard as quickly as practical, so data on room air cleaners, regardless of the technology used, can be collected on an apples-to-apples basis. A good surrogate for human coronaviruses and/or influenza viruses should be included as one of the test organisms. *Note: This standard may eventually be moved under a new standards committee formed by TG2.RAST once it is established. That would allow SSPC 185 to stay focused solely on ultraviolet technologies.*

- **Standard 185.4 (Subcommittee) – Method of Testing In-Room Ultraviolet Devices and Systems for Microbial Inactivation on Surfaces in a Test Room**
  The subcommittee is encouraged to continue working on the standard for rapid completion, but no changes to the scope are deemed necessary.

Appendices

Appendix 1 – Team-Generated Guidance

The F&D team developed the following guidance throughout their work:

- Filtration and Disinfection Slide Set (updated October 21, 2021): https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-filtration_disinfection-c19-guidance.pdf.
- Filtration and Disinfection Guidance Webpage (updated October 21, 2021): https://www.ashrae.org/technical-resources/filtration-disinfection.
- Filtration and Disinfection Frequently Asked Questions (7 total): https://www.ashrae.org/technical-resources/filtration-and-disinfection-faq.
- One Page Guidance Document, entitled In-Room Air Cleaner Guidance for Reducing COVID19 in Air in Your Space/Room (updated January 21, 2021): https://www.ashrae.org/file%20library/technical%20resources/covid-19/in-room-air-cleaner-guidance-for-reducing-covid-19-in-air-in-your-space-or-room.pdf.
- F&D Team directly answered over 135 questions from the public. This number does not count questions on filtration and disinfection answered directly by Bill Bahnfleth, Steve Hammerling, or other ASHRAE staff.

Appendix 2 – Technical References

Some key references, excluding those mentioned in Section 1.1 above, on the principal issues related to F&D and COVID-19 are provided below.

Reference List:

1. Kowalski W. 2010. Ultraviolet germicidal irradiation handbook: UVGI for air and surface disinfection. Berlin: Springer Science & Business Media.
2. Chun-Chieh Tseng & Chih-Shan Li (2007) Inactivation of Viruses on Surfaces by Ultraviolet Germicidal Irradiation, Journal of Occupational and Environmental Hygiene, 4:6,400-405.
3. Heßling M, Hönes K, Vatter P, Lingenfelder C. Ultraviolet irradiation doses for coronavirus inactivation – review and analysis of coronavirus photoinactivation studies. GMS Hyg Infect Control. 2020;15:Doc08
4. Heimbuch, B., & Harnish, D. (2019). Research to Mitigate a Shortage of Respiratory Protection Devices During Public Health Emergencies (Report to the FDA No. HHSF223201400158C).
5. Sagripanti J-L, Lytle CD. 2020. Estimated inactivation of coronaviruses by solar radiation with special reference to COVID-19. Photochemistry and Photobiology 96(4):731–737

6. Bianco A, Biasin M, Pareschi G, Cavalleri A, Cavatorta C, Fenizia C, Galli P, Lessio L, Lualdi M, Redaelli E. 2020. UV-C irradiation is highly effective in inactivating and inhibiting SARS-CoV2 replication. medRxiv DOI 10.1101/2020.06.05.20123463
7. Signify. 2020. Signify and Boston University validate effectiveness of Signify's UV-C light sources on inactivating the virus that causes COVID-19. Guildford: Signify.
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9. Inagaki H, Saito A, Sugiyama H, Okabayashi T, Fujimoto S. 2020. Rapid inactivation of SARSCoV-2 with Deep-UV LED irradiation. Emerging Microbes & Infections 9(1):1744–1747.
10. Simmons SE, et al. (2020). Deactivation of SARS-CoV-2 with pulsed-xenon ultraviolet light: Implications for environmental COVID-19 control. Infection Control & Hospital Epidemiology, https://doi.org/10.1017/ice.2020.399
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13. Azimi P and Stephens B. 2013. HVAC filtration for controlling infectious airborne disease transmission in indoor environments: Predicting risk reductions and operational costs. Building and Environment 70 (2013) 150-160, http://dx.doi.org/10.1016/j.buildenv.2013.08.025.
14. Kowalski and Bahnfleth, 2002. MERV Filter Models, Air Media, Summer issue.

ETF Research Team Summary of Research needs

The following are items that EHC found to be unaddressed by our most recent guidance (in order of importance):

1. *Infectious Aerosols.* Air infectious disease is not as focused compares to food and water. "There are, however, no ventilation guidelines or standards to specifically control the concentration of these pollutants indoors. None of the documents provide recommendations or standards for mitigating bacteria or viruses in indoor air, originating from human respiratory activities, per recently published document, "A Paradigm Shift to Combat Indoor Respiratory Infection".
2. *Increasing use of air cleaners*. There are many associated issues regarding their effectiveness, safety, and a clear need for relevant methods of testing and certification. How effective are they on different viruses, and impacts of byproducts they emit. Microbial - research to understand antimicrobial products in air and surfaces and the forming of superbugs. Research on test standard for the removal of ultrafine particles (UFP). Research into how best to test or even the levels of efficacy that are common would help design a useful standard. (e.g. Std 185.1, 2, & 3) Use of higher efficiency filters in non-healthcare settings. There is movement towards MERV 13 as a minimum standard for new systems and as an upgrade for existing systems. Associated issues are the inability of some existing systems to accommodate this level of upgrade, and energy use impact. On the other hand, there is an opportunity to rethink system design and develop components that successfully achieve this level of performance.
3. Better Indoor Air Quality: The demand for better IAQ will increase in the coming years. Paradigm shift in expectations for IAQ – towards health/productivity focus, including infection control outside healthcare environments. There is a need to formulate practical metrics for evaluating IAQ. Currently our ventilation standard is based on bioeflluence. Consider switching to ventilation base on "health" and research required to define "healhty air".
4. *Ventilation rates.* There is a trend towards increasing the ventilation air rates and air changes per hour (ACH) for indoor spaces. A proper guidance is required to assess the effectiveness of increased ACH and associated impact on energy demand. Cooling – using general rule of thumb, but does not models actual air flow in the space. Lack the clarity on whether the spaces are actually "mixed" or not, especially for overhead systems.
5. *Financial – Cost/Benefit*. Knowledge gap in developing solutions, best practice guidelines, assessment, diagnostic and EQ enhancement design tools, and economic models that can explicitly assign a monetary value to the costs and benefits of enhanced EQ.
6. *Climate Change.* Research on thermal comfort and chronic exposure - are we adapting to changing weather in any meaningful manner?
7. *Unvented combustion.* Although this is not a new trend, the lack of standards on the effect of these appliances on residential IEQ is trending as an issue. Research quantifying the effect of combustion products in residences is indicated as a need

going forward. Some helpful information can be found in the use of these products in the commercial and industrial built environment.

8. *IEQ as an aspect of resilience*. For a long time, discussions of resilience have revolved around protection of the building from earthquake, hurricane winds, flooding, etc. The emerging trend is to view protection of occupants during extreme outdoor and indoor events (e.g., wildfires and epidemics, respectively) as a core aspect of resilience. Cooking in general, gas cooking in specific, needs more research on its impact to IEQ. what extent can demand-controlled kitchen ventilation ("DCKV") address these issues. The primary research gap in acoustics is the correlation between performance and human perception in the built-environment. While the acoustical design metrics are based on human perception, the application and refinement of these metrics and performance criteria has not been well correlated with user's experiences and other measures of health and well-being. With respect to acoustics many of our minimum requirements assume constant noise or intrusion, but do not take into consideration the changes in time, amplitude, or frequency of events. Understanding this would likely help create more tangible "minimum requirements".
9. *Indoor agriculture.* Industrial indoor agriculture is a trending issue due to new market forces. Research on the impact of animals and plants on indoor environment can be enhanced. Many of the guidelines are lacking in information regarding these 2 aspects.
10. *Temporary Indoor Environments.* Temporary shelters - short term occupancy conditions (hurricanes, etc.) days to weeks, what is acceptable in short term conditions vs. conventional shelters. Also consider alternate accommodations (due to emergency) e.g. stadiums becoming shelters, etc. Is chronic exposure to certain indoor environments, even for short intervals, affecting health? Indoor air quality - chronic and short-term exposures at moderate levels of under ventilation and impact on health and performance, e.g., 1000-2000 ppm CO2 concentration equivalent.

Research Needs:

1) Development of new metrics for IEQ for spaces other than healthcare.
2) Development of testing and certification procedures for air cleaners.
3) Development of guidance for consumers related to air cleaners.
4) Efficacy of negative pressure spaces for non-healthcare environment.
5) Impact of air change rates on effectiveness of ventilation.
6) Renewed metrics for health and comfort measures.
7) Monetary benefits of health and wellness in built environment.
8) Real time measurement and monitoring of indoor contaminants.

May 10, 2022

ASHRAE ETF
Residential Team Report
August 2021

Introduction

This report is intended to help improve the Society's response to the life-safety threats presented by the COVID-19 pandemic. It can also assist ASHRAE technical committees as they improve ASHRAE guidance with respect to reducing risks of indoor transmission of airborne pathogens.

The report documents the collected experiences and recommendations of the residential team of ASHRAE's COVID-19 Epidemic Task Force. The team began work in February 2020 and met on a monthly basis through June of 2021. This report reflects the residential team's perspectives and recommendations as of August 2021.

Residential Team Members

Max Sherman (Team Leader)
Rick Karg (2021-2022 Chair, RBC)
Iain Walker (2018-2021 Chair, 62.2)
Steve Emmerich (Chair of GPC44P)
Simon Palin (Member, 90.2)
Brent Stephens (Member of ETF Science Applications Team)
Valerie Leprince (Liaison to AIVC and CEN TC156)
Chandra Sekhar (2018-2021 ASHRAE Board member)
Lew Harriman (Consultant to the team. Chair: 2021 Mold Document Revision Committee)

Section 1 - Lessons Learned

1. ASHRAE standards, handbook chapters or special publications that team members found helpful for advising the public and developing residential COVID guidance.

Very few existing standards or publications proved useful to our team members during this pandemic, perhaps because the hierarchy of risk factors and therefore relevant risk reduction measures for COVID-19 were not fully understood until late 2020. Most ASHRAE guidance was developed in prior years, for purposes other than reducing risks of COVID-19.

Four publications were useful as reminders of bare minimum requirements:

- ASHRAE Standards 62.1 and 62.2
- 2019 ASHRAE Handbook—APPLICATIONS - Chapter 62 - Ultraviolet air and surface treatment
- 2020 revision of the ASHRAE Position Document on Infectious Aerosols

Team recommendation: To be more responsive to pandemics and epidemics, ASHRAE senior leadership should consider directing standing committees to expand and update these documents and other relevant materials, based on lessons learned during the current pandemic.

2. Issues that remain unaddressed by residential COVID-19 guidance as of June 2021.

Four major issues have been researched and discussed by the residential team, but remain either unresolved or incomplete as of July 2021:

- **Residential outdoor air and filtered air delivery rates during airborne infection emergencies**. We lack an answer that is economically and physically achievable in existing

residential buildings worldwide. As a result, our residential team's guidance now emphasizes the use of portable HEPA air cleaners during an airborne pandemic. **Team recommendation:** Working with the support of the Environmental Health Committee, the Residential Building Committee should develop and publish ASHRAE guidance for limiting risks of transmission of airborne pathogens in residential buildings. Based on pandemic-related field research to date we recommend that ASHRAE outreach emphasize the use of portable HEPA air cleaners as the quickest, and best-documented means of reducing risks of airborne transmission.

- **Detailed guidance for portable HEPA air cleaners**. ASHRAE standards and publications are silent on the sizing, location, operation and maintenance of portable HEPA air cleaners. These are safe, relatively economical and easily-deployed in an emergency. They reduce airborne transmission risks very cost-effectively, compared to HVAC renovations. And although we respect the effort, the official ASHRAE one-page 2020 guidance on portable air cleaners developed by other ETF teams is overly theoretical, excessively computational, detached from commercial realities and worded only for professionals. The portable air cleaner guidance drafted by the residential team reflects best practices as outlined by the US EPA and is written in simple, direct language without the need for reader computation. Therefore the residential team's draft would be a better choice for ASHRAE guidance for residential building owners and occupants. **Team recommendations:** ASHRAE should adopt the residential team's guidance for pandemic response using portable HEPA air cleaners (for residential buildings) now, and in future publications. Further, the Residential Buildings Committee should collect and add best practices for placement and maintenance of these devices during a pandemic.
- **Guidance for natural ventilation**. Purchasing portable HEPA air cleaners is not an economically practical solution for the great majority of the global population. Because ASHRAE's mission is to serve humanity, ASHRAE needs to lead the development of guidance on opening windows that includes variations in climates, weather, outdoor air quality, and other considerations. Because of the complexity of the issue, we do not yet have simple guidance. Based on our extensive discussions, it will not be an easy task to develop universally useful guidance. **Team recommendation:** The Residential Buildings Committee should initiate a research-funded literature search to help the RBC and ASHRAE determine the probable extent of reliable risk reduction that can be achieved by opening windows in both high-rise and low-rise residential buildings.
- **ASHRAE needs data that quantifies the pandemic-relevant effectiveness of our recommended, quickly-deployable filtration alternatives for existing homes.** Although our team and the ETF has provided what we firmly believe to be useful guidance for emergency filtration during this pandemic, there are few if any studies that have quantified airborne viral *removal from occupied spaces* when *existing* residential systems are upgraded with MERV-13 filters, or when residential spaces are equipped with portable HEPA air cleaners. **Team recommendation:** ASHRAE TC 2.4 (Particulate Air Contaminants and Particulate Contaminant Removal Equipment) should initiate research to quantify viral

removal effectiveness (removal from occupied spaces) of stand-alone devices and system upgrades that can be deployed quickly and economically in residential buildings during a pandemic. As a minimum, these should include portable, consumer-grade air cleaners rated with a high CADR, and residential HVAC systems retrofitted with particle filters that are rated at MERV-13 (and higher if necessary). The fundamental questions include: to what extent and for how long are consumer-grade portable air filters—or existing central systems with upgraded filters—capable of reducing airborne viral concentration in occupied spaces.

3. Recommended New/Changed Residential Guidance (with justification and wording)

See sections 2 and 4 for specific recommendations and justification for same.

4. Issues outside the residential team's assigned responsibilities that affect the effectiveness of ASHRAE's pandemic response.

To improve pandemic response, the ASHRAE Board of Directors may wish to consider these observations and suggestions:

- **Rather than "ventilation air", ETF guidance should use the term "non-infectious air" along with a clear definition and explanation of that term.** Our team members believe that in the residential space there is widespread confusion about the combination of ventilation and filtered air that ASHRAE recommends to simultaneously dilute and remove airborne virus. We believe that a universal and publically comprehensible definition and explanation is important, but beyond the scope of our team's responsibilities. **Team recommendation:** The ETF should consider using the term "non-infectious air." We suggest that a universal definition (applicable only to COVID-19 guidance) could be:
  - Non-infectious air: For the purpose of ASHRAE COVID-19 risk reduction guidance, the term "non-infectious" refers to supply air that has been cleaned and disinfected. This includes air filtered to a level of MERV-13 or higher, or air that comes from outdoors.
- **"Safe" non-infectious air flow rates are not practical to either define or implement.** Public and professional expectations remain that "somebody" (ASHRAE) should determine how much ventilation will "keep people safe." The ETF's scientific team made extensive assessments of available outbreak studies, and developed a complex but potentially credible methodology for recommending ventilation rates. Unfortunately, the number of assumptions and their uncertainty does not allow establishment of air flow rates that are physically possible and economically practical. **Team recommendation:** It would be best for the Society to candidly and clearly state that although increasing ventilation and filtration will certainly reduce risks, there are too many unknowns of the numbers and infective status of occupants for any amount of uninfected air to assure "safety" inside buildings. Consequently, focusing on vaccination, masking and reducing occupancy should be the primary means of reducing risks rather than relying on HVAC measures to compensate for the substantial risk of airborne infection when these primary means of risk reduction are not employed.

- **Archive airborne pandemic lessons in a special publication.** To speed and improve future pandemic response by the worldwide HVAC community, a new special publication is probably the logical place to archive ASHRAE's airborne infection guidance. We consider a special publication to be a better option than a handbook chapter for two reasons: information about pandemics is not generally useful at other times, and a special publication can record the specifics of this and similar pandemics for reference as an historical event, rather than attempting to generalize guidance that may or may not be useful for future pandemics. Development of this special publication is probably best led by the Environmental Health Committee because other ASHRAE bodies lack the sufficiently broad remit required for this effort. **Team recommendation:** The Environmental Health Committee should develop a new special publication that illuminates the lessons learned about risk reduction by providing specific examples of documented events during recent airborne pandemics, e.g.: SARS-CoV-1, MERS and SARS-CoV-2 and SARS-CoV-2 (Delta). In appendix 2 of this report, the residential team provides relevant, peer-reviewed references that could assist the EHC in generating this publication.
- **ASHRAE should greatly increase the Society's emphasis on HVAC commissioning and re-commissioning.** Professionals (and the public) need to know that systems are in fact filtering and delivering ventilation air to each space, per design. Historically, this has been done very poorly or not at all. In most occupied spaces, neither ventilation nor filtration is measured and displayed in real time. Consequently, both often become wildly excessive or grossly inadequate, wasting energy and increasing risks of airborne infection. This might need new standards and/or better diagnostic tools and practices, and possibly third-party certification programs. **Team recommendation:** ASHRAE TC 7.9 (Building Commissioning) should develop short-form COVID-19 recommissioning checklists that guide building owners and operators in measuring and adjusting the HVAC system parameters *that most affect airborne transmission risk reduction.* Given the diversity of worldwide building types and functions, it will probably be necessary to develop more than a single checklist. Consider separate checklist for each group of buildings that have similar risk profiles and that share similar system types. For the residential checklist, we recommend collaboration with the Residential Building Committee, and also suggest that TC-7.9 and RBC consider including these three measures:
    - While wearing a well-fitted N-95 mask, visually inspect all air filters and change any that are obviously soiled. Then bag, seal and safely dispose of used filters.
    - Measure the external static pressure of the existing systems' fans to evaluate their ability to accommodate filters rated at MERV-13 without significant loss of heating, cooling and ventilation effectiveness. Based on results of this measurement, when possible upgrade central system filtration to at least MERV-13. When not possible (or when no central system is present or when vulnerable individuals occupy the indoor spaces in question) recommend the use of portable HEPA air cleaners to reduce airborne infection risks.

- Measure and adjust any available ventilation air stream to the flow design values, given the system's current limitations.

- **ASHRAE should commit to becoming a publicly obvious resource.** Historically, ASHRAE has not had a great deal of successful ***public*** engagement. For 100 years, we as an organization have spoken largely to ourselves, and only sometimes to allied professions. In light of what we now know about mitigating the pandemic, it is important to cement ASHRAE's position as a key resource in addressing airborne pandemics. Beyond our professional responsibility to share our knowledge in addressing public health crises, ASHRAE is in a unique position to act on its vision to create "a healthy and sustainable built environment for all". Also, the increased revenue that comes from enhanced worldwide public awareness would be a welcome enhancement to ASHRAE's financial sustainability.
  Team recommendation: In the near term, ASHRAE senior leadership should consider taking advantage of the once-in-a-lifetime opportunity presented by the current worldwide interest in airborne infection risk reduction. This could be accomplished by engaging a consumer PR agency (one that has demonstrated effective PR for and understanding of technical messages) to work in collaboration with ASHRAE marketing staff to provide ASHRAE's Senior Leadership with continuous measurement of ASHRAE's pandemic guidance communication effectiveness through June of 2022. Two persuasive metrics of public effectiveness would be: percent of U.S. building owners and homeowners who know that ASHRAE exists, and has made credible pandemic risk reduction guidance available at no charge, and; percent of the worldwide community of building design professionals who are similarly aware that ASHRAE and its COVID-19 guidance exists.

- In the long term, leadership could also consider identifying and engaging an organization can help ASHRAE develop, maintain and *measure a consumer communication program* that becomes and remains effective and relevant to the public's concerns with respect to building science and HVAC issues.

Section 2 – List of Team-Generated Guidance

The residential team has developed text, graphics and video clips that ASHRAE standing and technical committees may wish to consider when developing more durable, long-term guidance. Available documents and videos include:

- **Residential guidance main page**. [LINK]
- **One-page guidance document for homeowners and apartment dwellers**. [LINK]
- **Guidance for multifamily facility owners and managers**. [LINK]
- **Frequently asked questions and answers for homeowners and apartment dwellers**. [LINK]
- **Guidance for Communities of Faith)**. [LINK]
- **Guidance for Temporary Dining Structures** [LINK]

Section 3 – Transition Plan

See sections 1 and 2 for specific, near-term recommendations that transfer the suggestions of the residential team to specific technical committees.

More generally, we propose that on September 1st 2021 (or a later date as approved by the ETF, the residential team intends to cease regular meetings and transfer responsibility for further adjustment of airborne epidemic guidance to the Residential Building Committee (RBC) and the Environmental Health Committee (EHC), along with the specific recommendations for further work as described in section 1.

Note that our team has been privileged to have had the current Chair of RBC as one of our members from the beginning of the ETF activities. We believe our 18-month collaboration with RBC will facilitate the smooth transition of responsibilities to that committee. Supporting that belief is the fact that the RBC Chair has already begun formal collaboration with the EHC to provide effective transfer of the work of our residential ETF team.

Appendices

Appendix 1 – Team-Generated Guidance

- Residential guidance main page. [LINK]
- One-page guidance document for homeowners and apartment dwellers. [LINK]
- Guidance for multifamily facility owners and managers. [LINK]
- Frequently asked questions and answers for homeowners and apartment dwellers. [LINK]
- Guidance for Communities of Faith). [LINK]
- Guidance for Temporary Dining Structures [LINK]

Appendix 2 – Technical References

Suggested references are divided into sections titled for some of the principal issues related to HVAC and COVID-19. Not all of these studies are specifically residential. But all directly support the judgements and decisions that professionals and building owners have had to make during the current pandemic. **Team recommendations:** Technical experts assigned by the ASHRAE ETF leadership should consider:

a. Reviewing these studies to determine if they merit long-term inclusion in the ETF technical references.

b. Adopting the criterion that no reference be included in ETF references that lacks a brief explanation of why the reference is included in the list.

c. Adopting (or adapting) the section titles below as an aid to navigation for current and future readers of ASHRAE's COVID-19 technical references.

The primary route of COVID-19 transmission is airborne, via indoor air

COVID-19 transmission is predominantly airborne. This is a fact that ASHRAE and allied engineering and research communities documented and with which public health authorities now agree. It is exceptionally important for HVAC community and the public to understand that the odds of transmitting COVID-19 are overwhelmingly greater indoors than outdoors. And because the virus is airborne, transmission is affected—for better and for worse—by the capabilities and operation of each building's HVAC systems.

• *Nishiura et al 2020. Closed environments facilitate secondary transmission of coronavirus disease 2019 (COVID-19) DOI: https://doi.org/10.1101/2020.02.28.20029272*

A total of 110 cases were examined among eleven clusters and sporadic cases, and investigated who acquired infection from whom. The odds that a primary case transmitted COVID-19 in a closed environment was 18.7 times greater compared to an open-air environment (95% confidence interval).

• *Qian, Miao, Li et al, 2020. Indoor transmission of SARS-CoV-2 DOI: 10.1111/ina.12766*

Three hundred and eighteen outbreaks with three or more cases were identified, comprising a total of 1245 confirmed cases in 120 prefectural cities. Home-based outbreaks were the dominant category (254 of 318 out- breaks; 79.9%), followed by transport-based outbreaks (108; 34.0%), and many out- breaks occurred in more than one category of venue. All identified outbreaks of three or more cases occurred in indoor environments, which confirm that sharing indoor spaces with one or more infected persons is a major SARS-CoV-2 infection risk.

• *Tang, Marr, Li & Dancer (2021) Covid-19 has redefined airborne transmission https://doi.org/10.1136/bmj.n913 British Medical Journal - Editorial*

"…Covid-19 may well become seasonal, and we will have to live with it as we do with influenza. So governments and health leaders should heed the science and focus their efforts on airborne transmission. Safer indoor environments are required, not only to protect unvaccinated people and those for whom vaccines fail, but also to deter vaccine resistant variants or novel airborne threats that may appear at any time. Improving indoor ventilation and air quality, particularly in healthcare, work, and educational environments, will help all of us to stay safe, now and in the future…"

• *Morawska, Allen, Bahnfleth et al 2021. A paradigm shift to combat indoor respiratory infection: Building ventilation systems must get much better. Science 372 (6543), 689-691. DOI: 10.1126/science.abg2025*

"…Governments have for decades promulgated a large amount of legislation and invested heavily in food safety, sanitation, and drinking water for public health purposes. By contrast, airborne pathogens and respiratory infections, whether seasonal influenza or COVID-19, are addressed fairly weakly, if at all, in terms of regulations, standards, and building design and operation, pertaining to the air we breathe…" "…National comprehensive IAQ standards must be developed, promulgated, and en- forced by all countries. Some countries have IAQ standards, but none are comprehensive enough to include airborne pathogens. In most countries that have IAQ standards, there are no enforcement procedures. Most countries do not have any IAQ standards…"

- *Lu, J. et al. (2020). "COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China, 2020." Emerging Infectious Disease journal 26(7).DOI: https://doi.org/10.3201/eid2607.200764*

From January 26 through February 10, 2020, an outbreak of 2019 novel coronavirus disease (COVD-19) affected 10 persons from 3 families who had eaten at the same air-conditioned restaurant in Guangzhou, China. One of the families had just traveled from Wuhan, Hubei Province, China. This study performed a detailed investigation that linked these 10 cases together.

• *Li Y, Qian H, Hang J, Chen X, Cheng P, Ling H, Wang S, Liang P, Li J, Xiao S, Wei J, Liu L, Cowling BJ, Kang M, Probable airborne transmission of SARS-CoV-2 in a poorly ventilated restaurant, Building and Environment (2021), https://doi.org/10.1016/j.buildenv.2021.107788* [This is a separate, updated and expanded version of the event described above.]

These two now-classic papers about the restaurant event in Guangzhou demonstrate how and why indoor COVID-19 transmission is an airborne problem that is heavily influenced by the amount of dilution provided—or not provided—by outdoor air ventilation.

• *Wei and Li. Airborne spread of infectious agents in the indoor environment. American Journal of Infection Control 44 (2016) S102-S108*

Useful information graphics and a simple explanation of differences between short and long-range particle transmission.

- *G. Buonanno, L. Morawska, L. Stabile, Quantitative assessment of the risk of airborne transmission of SARS-CoV-2 infection: prospective and retrospective applications. Environment International 145, 106112 (2020). https://www.sciencedirect.com/science/article/pii/S0160412020320675?via%3Dihub*

This study presents a novel approach for quantitative assessment of the individual infection risk of susceptible subjects exposed in indoor microenvironments in the presence of an asymptomatic infected SARS-CoV-2 subject.

• *Bazant & Bush 2021 - A guideline to limit indoor airborne transmission of COVID-19 https://doi.org/10.1073/pnas.2018995118*

The authors build on models of airborne disease transmission in order to derive an indoor safety guideline that would impose an upper bound on the "cumulative exposure time," the product of the number of occupants and their time in an enclosed space. They demonstrate how this bound depends on the rates of ventilation and air filtration, dimensions of the room, breathing rate, respiratory activity and face mask use of its occupants, and infectiousness of the respiratory aerosols.

• *Greenhalgh et al 2021 - Ten scientific reasons in support of airborne transmission of SARS-CoV-2 https://doi.org/10.1016/S0140-6736(21)00869-2*

This short paper summarizes the case that proposes that the primary route of COVID-19 indoor transmission is airborne. Occupant density, duration of exposure and strength of vocalization increase risks of transmission. Viral concentration and duration of exposure determine transmission risks. Concentration varies with number of occupants, types of vocalization and activity levels and airflow direction from infected to non-infected occupants. Understanding and quantifying these factors is useful for guiding the selection and implementation of risk reduction measures.

• *Shen, Ye et al. PREPRINT. Airborne Transmission of COVID-19: Epidemiologic Evidence from Two Outbreak Investigations (March 10, 2020). http://dx.doi.org/10.2139/ssrn.3567505*

This study provide a good illustration of how we know the problem is airborne – most infected people > 2m away, and how there are big differences in susceptibility between people - people within 2m not infected.

• *Coleman, Tay, Tan, et al, Viral Load of SARS-CoV-2 in Respiratory Aerosols Emitted by COVID-19 Patients while Breathing, Talking, and Singing, Clinical Infectious Diseases, 2021;, ciab691, https://doi.org/10.1093/cid/ciab691*

Using a G-II exhaled breath collector, the study measured viral RNA in coarse and fine respiratory aerosols emitted by COVID-19 patients during 30 minutes of breathing, 15 minutes of talking, and 15 minutes of singing. Thirteen participants (59%) emitted detectable levels of SARS-CoV-2 RNA in respiratory aerosols, including 3 asymptomatic and 1 presymptomatic patient. Viral loads ranged from 63–5,821 N gene copies per expiratory activity per participant, with high person-to-person variation. Patients earlier in illness were more likely to emit detectable RNA. Two participants, sampled on day 3 of illness, accounted for 52% of the total viral load. Overall, 94% of SARS-CoV-2 RNA copies were emitted by talking and singing. Interestingly, 7 participants emitted more virus from talking than singing. Overall, fine aerosols constituted 85% of the viral load detected in the study study. Virus cultures were negative.

• *Schijven et al. 2021 - Quantitative Microbial Risk Assessment for Airborne Transmission of SARS-CoV-2 via Breathing, Speaking, Singing, Coughing, and Sneezing. https://doi.org/10.1289/EHP7886.*

The expelled volume of aerosols is highest for a sneeze, followed by a cough, singing, speaking, and breathing. After 20 min of exposure, at 107 RNA copies/mL in mucus, all mean illness risks were largely estimated to be below 0.001, except for the "high" sneeze scenario. One air exchange per hour reduced risk of illness by about a factor of 2. Six air exchanges per hour reduced risks of illness by a factor of 8–13 for the sneeze and cough scenarios and by a factor of 4–9 for the other scenarios.

• *Standnytskyi et al 2020. The airborne lifetime of small speech droplets and their potential importance in SARS-CoV-2 transmission www.pnas.org/cgi/doi/10.1073/pnas.2006874117*

Speech droplets generated by asymptomatic carriers of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) are a likely mode of disease transmission. Highly sensitive laser light scattering observations revealed that loud speech can emit thousands of oral fluid droplets per second. These observations confirm that there is a substantial probability that normal speaking causes airborne virus transmission in confined environments.

Occupant masks greatly reduce viral loads and risks of transmission

The viral load determines what HVAC risk reduction measures will be needed. Wearing masks indoors greatly reduces viral load. So it is critical to insist that in future pandemics, policymakers and HVAC professionals understand and act to implement this most important risk reduction measure. These early and important studies showed that ventilation and filtration have little risk reduction value if masks are not worn to limit the source strength of viral generation in rooms occupied by groups.

• *Wang, Tian et al. 2020. Reduction of secondary transmission of SARS-CoV-2 in households by face mask use, disinfection and social distancing: a cohort study in Beijing, China doi:10.1136/bmjgh-2020-002794*

The risk of household transmission was 18 times higher with frequent daily close contact with the primary case (OR=18.26, 95% CI 3.93 to 84.79), and four times higher if the primary case had diarrhoea (OR=4.10, 95% CI 1.08 to 15.60). Household crowding was not significant. The secondary attack rate in families was 23.0% (77/335). Face mask use by the primary case and family contacts before the primary case developed symptoms was 79% effective in reducing transmission (OR=0.21, 95% CI 0.06 to 0.79)

• *Chu, Akl et al 2020. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. Lancet. https://doi.org/10.1016/ S0140-6736(20)31142-9*

This search identified 172 observational studies across 16 countries and six continents, with no randomised controlled trials and 44 relevant comparative studies in health-care and non-health-care settings (n=25,697 patients). Transmission of viruses was lower with physical distancing of 1 m or more, compared with a distance of less than 1 m; protection was increased as distance was lengthened. Face mask use could result in a large reduction in risk of interaction infection (n=2647; aOR 0·15, 95% CI).

Physical and operational realities of HVAC in existing buildings

Real-world emergency retrofit opportunities and challenges are probably the most pressing issues during pandemics. To keep HVAC solutions practical and achievable in any short period, those who develop guidance need to understand the practical factors affecting existing systems - not new buildings and new systems.

• *Chan, Xiwang, Singer et al. 2020. Ventilation rates in California classrooms: Why many recent HVAC retrofits are not delivering sufficient ventilation. https://doi.org/10.1016/j.buildenv.2019.106426*

This study visited 104 classrooms from 11 schools that had recently been retrofitted with new heating, ventilation, and air-conditioning (HVAC) units. CO_2 concentration, room and supply air temperature and relative humidity, and door opening were measured for four weeks in each classroom. Field inspections identified problems with HVAC equipment, fan control, and/or filter maintenance in 51% of the studied classrooms. Better oversight on HVAC system installation and commissioning are needed to ensure adequate classroom ventilation. Periodic testing of ventilation systems and/or continuous real-time CO_2 monitoring (either as stand-alone monitors or incorporated into thermostats) is recommended to detect and correct ventilation problems.

• *Ueno, Lstiburek and Bergey 2012. Multifamily Ventilation Retrofit Strategies. U.S Department of Energy, Building America Program Report, National Renewable Energy Laboratory Prepared under Subcontract No. KNDJ-0-40337-00*

An excellent detailed and illustrated introduction to real-world configurations and challenges of multifamily ventilation systems in North America. The report includes measured values of air tightness and air transfer between spaces.

• *Corsi, Miller, Marr et al, 2021. Designing infectious disease resilience into school buildings through improvements to ventilation and air cleaning. The Lancet COVID-19 Commission: covid19commission@unsdsn.org*

A neat summary of the health benefits of improved ventilation and filtration in schools, including the reduction of risk of transmission via airborne viruses.

• *Foster, A and Kinzel, M. 2020. Estimating COVID-19 exposure in a classroom setting: A comparison between mathematical and numerical models. Phys. Fluids 33, 021904 (2021); doi 10.1063/5.0040755*

"…This effort provides a detailed comparison of the two methods for a classroom scenario with masked habitants and various ventilation conditions. For both cases, there was a significant amount of variation in individual transmission route infection probabilities (up to 220%), local air patterns were the main contributor driving the variation, and the separation distance from infected to susceptible was the secondary contributor; (masks are shown to have benefits from interacting with the thermal plume created from natural convection induced from body heat, which pushes aerosols vertically away from adjacent students…"

Central System Particle Filtration Can Reduce Risks

Portable HEPA and central system MERV-13 filtration provide cost-effective means of reducing transmission risks. And when speed of response is important, portable HEPA units are a very practical means of risk reduction for small group gatherings, including residential spaces. There was much confusion about the value and the costs of different particle filtration levels for COVID-19. These papers provide an excellent foundation for understanding the real-world capabilities and limitations of central system filtration.

• *Johnson et al. (2011). "Modality of human expired aerosol size distributions". Journal of Aerosol Science, Vol. 42, Issue 12, pp. 839-851. https://doi.org/10.1016/j.jaerosci.2011.07.009*

This study discusses particle size and why it matters, supporting a reasonable conclusion that HEPA filters in central systems are probably not necessary or more useful than MERV-13.

- *Mao et al. (2020) Transmission Risk of infectious droplets in physical spreading process at different times: a review. Building and Environment. https://doi.org/10.1016/j.buildenv.2020.107307*

Large droplets are the principle means of disease transmission; thus, if they are only blocked by a homemade mask initially, it significantly contains the epidemic. The early phase of contact, such as close-contact and short-range transmission, has the highest infection risk; therefore, social distancing can effectively keep the susceptible population from inhaling active viruses.

- *Gettings J, Czarnik M, Morris E, et al. Mask Use and Ventilation Improvements to Reduce COVID-19 Incidence in Elementary Schools — Georgia, November 16–December 11, 2020. MMWR Morb Mortal Wkly Rep 2021;70:779–784. DOI: http://dx.doi.org/10.15585/mmwr.mm7021e1*

The combination of masks, ventilation and MERV-13 filtration reduced incidence of COVID-19 by 48%, based on data from 1,461 elementary schools in Georgia.

- *Li, 2021 - Hypothesis: SARS-CoV-2 transmission is predominated by the short-range airborne route and exacerbated by poor ventilation. Indoor Air May 2021 - https://doi.org/10.1111/ina.12837*

The significant adverse effect of poor ventilation (≤3 L/s per person) on short-range airborne transmission has not been recognized. Existing ventilation standards, such as ASHRAE 62.1, do not consider infection control as their objective. There is a need to develop a set of minimum ventilation rates for indoor spaces used for different activities. A home may have adequate ventilation for existing family members, but when relatives or friends visit, the occupancy situation changes and the ventilation may become inadequate. This may explain the significant number of outbreaks observed after family gatherings. The predominance of the short-range airborne route of SARS-CoV-2 transmission strongly suggests the need for healthcare workers who care for COVID-19 patients to wear an N95 mask.

• *Li, Alavy, Zhang, Siegel. 2019 Final Report: ASHRAE Research Project 1649-RP IAQ and Energy Implications of High Efficiency Filters in Residential Buildings.*

The central effort of the investigation was a year-long field campaign in 20 homes, each of which had four levels of filtration (nominal MERV 8 uncharged media, and MERV 8, MERV 11, and MERV 14 charged-media), each installed for three months. Long-term effectiveness was very low and has large variations. This is partially a filter effect but is mostly a runtime effect. Another way of saying this is that in the sample of homes where runtimes were generally small (median annual runtime of 9.6%), the filter did not strongly influence particle concentrations because it was not being used very much. The efficiency impacts are important, but runtime (and more broadly effective recirculation rate) imposes a practical limit on the impact of any filter.

• *Azimi & Stephens. 2013 HVAC Filtration for controlling infectious airborne disease transmission in indoor environments: Predicting risk reductions and operational costs. http://dx.doi.org/10.1016/j.buildenv.2013.08.025*

This work describes and applies a methodology for estimating the impact of recirculating heating, ventilating, and air-conditioning (HVAC) particle filters on the control of size-resolved infectious aerosols in indoor environments. Overall, recirculating HVAC filtration was predicted to achieve risk reductions at lower costs of operation than equivalent levels of outdoor air ventilation, particularly for MERV 13e16 filters. Medium efficiency filtration products (MERV 7e11) are also inexpensive to operate but appear less effective in reducing infectious disease risks.

• *Stephens and Seigel 2013. Ultrafine particle removal by residential heating, ventilating, and air-conditioning filters doi:10.1111/ina.12045*

This work uses an in situ filter test method to measure the size-resolved removal efficiency of indoor-generated ultrafine particles (approximately 7–100 nm) for six new commercially available filters installed in a recirculating heating, ventilating, and air-conditioning (HVAC) system in an unoccupied test house. A modeling effort using these measured values for new filters and other inputs from real buildings shows that MERV 13–16 filters could reduce the indoor proportion of outdoor UFPs (in the absence of indoor sources) by as much as a factor of 2–3 in a typical single-family residence relative to the lowest efficiency filters, depending in part on particle size.

• *Zhang, Huntley et al 2020. Study of Viral Filtration Performance of Residential HVAC Filters. ASHRAE Journal, August 2020.*

This study measured the viral removal performance of residential filters in a laboratory test environment (as opposed to a typical residential HVAC system). MERV-13 filters were shown to be 80 to 97% effective for viral particles.

• *Johnson, Morawska et al 2020. Modality of human expired aerosol size distributions. doi:10.1016/j.jaerosci.2011.07.009*

This study quantified the volume and particle size distribution of droplets from various forms of human expiration. This is useful information when considering filtration alternatives for risk reduction for different types of indoor activities.

Portable HEPA filters Can Reduce Risks

In field research, portable HEPA's proved to be an effective and much less invasive and lower cost means of risk reduction compared to upgrading central HVAC systems. This fact must not be overlooked in future ASHRAE guidance.

• *Lindsley WG, Derk RC, Coyle JP, et al. 2021. Efficacy of Portable Air Cleaners and Masking for Reducing Indoor Exposure to Simulated Exhaled SARS-CoV-2 Aerosols — United States, 2021. MMWR Morb Mortal Wkly Rep 2021;70:972–976. DOI: http://dx.doi.org/10.15585/mmwr.mm7027e1external icon*

To investigate the effectiveness of portable HEPA air cleaners and universal masking at reducing exposure to exhaled aerosol particles, the investigation team used respiratory simulators to mimic a person with COVID-19 and other, uninfected persons in a confer- ence room. The addition of two HEPA air cleaners that met the Environmental Protection Agency (EPA)–recommended clean air delivery rate (CADR) (5) reduced overall exposure to simulated exhaled aerosol particles by up to 65% without universal masking. Without the HEPA air cleaners, universal masking reduced the combined mean aerosol concentration by 72%. The combination of the two HEPA air cleaners and universal masking reduced overall exposure by up to 90%. The HEPA air cleaners were most effective when they were close to the aerosol source. These findings suggest that portable HEPA air cleaners can reduce exposure to SARS-CoV-2 aerosols in indoor environments, with greater reductions in exposure occurring when used in combination with universal masking.

• *Blocken B, van Druenen T, Ricci A, Kang L, van Hooff T, Qin P, Xia L, Ruiz CA, Arts JH, Diepens JFL, Maas GA, Gillmeier SG, Vos SB, Brombacher AC. Ventilation and air cleaning to limit aerosol particle concentrations in a gym during the COVID-19 pandemic. Build Environ. 2021 Apr 15;193:107659. doi: 10.1016/j.buildenv.2021.107659. Epub 2021 Feb 4. PMID: 33568882; PMCID: PMC7860965.*

This paper presents measurements of aerosol particle concentrations in a gym, where saliva aerosol production is pronounced. 35 test persons performed physical exercise and aerosol particle concentrations, CO2 concentrations, air temperature and relative humidity were obtained in the room of 886 m3. A separate test was used to discriminate between human endogenous and exogenous aerosol particles. Aerosol particle removal by mechanical ventilation and mobile air cleaning units was measured. The gym test showed that ventilation with air-change rate ACH = 2.2 h−1, i.e. 4.5 times the minimum of the Dutch Building Code, was insufficient to stop the significant aerosol concentration rise over 30 min. Air cleaning alone with ACH = 1.39 h−1 had a similar effect as ventilation alone. Simplified mathematical models were engaged to provide further insight into

ventilation, air cleaning and deposition. It was shown that combining the above-mentioned ventilation and air cleaning can reduce aerosol particle concentrations with 80 to 90%, depending on aerosol size. This combination of existing ventilation supplemented with air cleaning is energy efficient and can also be applied for other indoor environments.

• *Curtius, Granzin and Schrod. 2021. Testing mobile air purifiers in a school classroom: Reducing the airborne transmission risk for SARS-CoV-2 https://doi.org/10.1080/02786826.2021.1877257*

This study tested the efficiency and practicability of operating four air purifiers equipped with HEPA filters in a high school classroom while regular classes were taking place. We monitored the aerosol number concentration for particles >3nm at two locations in the room, the aerosol size distribution in the range from 10nm to 10mm, PM10 and CO_2 concentration. For comparison, we performed similar measurements in a neighbor- ing classroom without purifiers. In times when classes were conducted with windows and door closed, the aerosol concentration was reduced by more than 90% within less than 30min when running the purifiers (air exchange rate 5.5h1). The reduction was homogeneous throughout the room and for all particle sizes. Staying for 2 h in a closed room with a highly infective person, we estimate that the inhaled dose is reduced by a factor of six when using air purifiers with a total air exchange rate of 5.7 h1.

• *Bluyssen, Ortiz and Zhang 2020. The effect of a mobile HEPA filter system on 'infectious' aerosols, sound and air velocity in the SenseLab https://doi.org/10.1016/j.buildenv.2020.107475*

In this study the 'air cleaning' effect as well as the effect on sound and air velocity (draught risk) of a mobile High- Efficiency Particulate Air (HEPA) filter system was tested for different settings and positions in the Experience room of the SenseLab. For the removal of aerosols simulated by air-filled soap bubbles in front of the subject, the mobile HEPA filter system performed better as compared to the 'No ventilation' regime, for all settings and both positions, and for some settings, even better than all the tested mixing ventilation regimes. The use of a mobile HEPA filter system seems a good additional measure when only natural ventilation options are available.

Duration of infective capabilities of SARS-CoV-2 in air

Infective duration varies by virus. Early in the pandemic, there had been much advocacy of humidification as a means of reducing transmission risks. And although it is true as a general rule that humidity influences viral survival over long periods, aerosolized SARS-CoV-2 remains viable for at least 16 hours at high humidity (53%). Perhaps as a consequence, RH has proved much less influential during this pandemic than lack of vaccination, ventilation and filtration. That said, humidity and survival on surfaces may turn out to be important during the next pandemic. So these references can serve as a starting point for discussion that will almost certainly be repeated during the next emergency.

• *Influence of atmospheric humidity in transmission of SARS-CoV-2 WMO 2020. Review on Meteorological and Air Quality Factors Affecting the COVID-19 Pandemic. World Meteorological Organization WMO-1262 ISBN 978-92-63-11262-0*

This study reviewed the global history of COVID-19 infection during 2020, and concluded that atmospheric humidity (outdoor dew point) was not an influential factor. Governmental policies and wearing of masks were major factors. This reference points out the limitations of HVAC

interventions compared to the importance of building occupant behavior, governmental policies and their implementation.

• *Fears, Klimstra et al 2020. Persistence of Severe Acute Respiratory Syndrome Coronavirus 2 in Aerosol Suspensions. DOI: https://doi.org/10.3201/eid2609.201806*

This study found that as an aerosol, the virus remained viable for 16 hours in air at 23°C ±2°C and 53% RH ±11% (probably in excess of 16 hours).

• *Van Doremalen et al. (2020). "Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1." New England Journal of Medicine 382(16): 1564-1567*

Provides measured stability of the virus when airborne: less than 30% reduction of the viable population measured three hours after injection as an aerosol into air maintained at 21-24°C and 40% RH.

• *Yang and Marr. 2011. Dynamics of Airborne Influenza A Viruses Indoors and Dependence on Humidity. PLoS ONE 6(6): e21481. doi:10.1371/ journal.pone.0021481*

Influenza kills millions of people every year. The characteristics are different and much less infective than SARS-CoV-2. But flu transmission is also airborne and deaths are repeated by the million, every year. Because ASHRAE guidance on airborne infection needs to go beyond the current pandemic, this information can be helpful.

Executive Summary

This report is intended to help improve the Society's response to the life-safety threats presented by the COVID-19 and future pandemics. It can also assist ASHRAE technical committees as they seek to improve ASHRAE standards and guidance with respect to indoor air quality (IAQ) and to reducing risks of indoor transmission of airborne pathogens and infectious aerosols.

The report documents the collected experiences and recommendations of the Commercial Team of ASHRAE's COVID-19 Epidemic Task Force. This report reflects the Commercial Team's perspectives and recommendations.

The Commercial Team answered the commercial team related questions on the FAQ page, and has the following technical guidance:

- Commercial Guidance

Worked with technical groups to develop the following technical guidance documents:

- In-Room Air Cleaner Guidance for Reducing Covid-19 In Air In Your Space/Room, January 21, 2021
- Guidance for Polling Place HVAC Systems, August 19, 2020
- Environmental Health Emerging Issue Brief, Pandemic COVID-19 and Airborne Transmission
- Communities of Faith Guidance
- Building Readiness Guidance

The commercial guide could provide pertinent technical information to be incorporated as concerns with a pandemic, if not already in their documents, for thirty (30) ASHRAE Technical Groups (SPC, GPC, TC, MTG).

The following are open issues:

- **Acceptable Risk Level of a Specific Office:** What is the risk level of an office the occupants want to achieve?

- **New COVID-19 Variants and HVAC System Types:** Since the risk level is not linear, new variants with significant higher number of viral loads may not favor systems with low air changes and will increase the risk significantly.

- **People:**
  - Design for "average" person versus design for "individuals" based on vulnerability
  - Design for "super spreader" or design for an average infectious material?

- **Air Flow:**
  - Underfloor supply systems versus overhead VAV system
  - Target Equivalent Outdoor Air quantity required during occupancy for acceptable risk control in different commercial settings during airborne infection emergencies

  - Design guidance on the impact of room air distribution to reduce the direct transmission of infectious aerosols
  - Impact of humidity and dirt on MERV rated filters versus MERV-A
  - MERV-13 filter and drop in efficiency especially in pleated 1" filter for fan coil, fan powered boxes, and other terminal devices
  - Impact of Flushing Spaces on Contaminants and Particles

- **Furniture, equipment, people, and other indoor objects impacts:** accounting for furniture and objects in the space that can create stagnant air with lower air changes.
- **Actual measurement:** measurement of actual virus reduction versus the Core Recommendations and equivalent outdoor air approach predictions.

The following are issues beyond this guidance that ASHRAE should address:

- **Develop a Generation of Healthier Buildings Against Holistic of Air Quality Threats**
- **Develop New Standards:**
  - **Indoor Environmental Quality and Audit Document**
  - **Method of test for air cleaning devices like Std 185 for UV**
- **Develop Dynamic Thermal Research and Guidelines**
- **Develop research in actual field performances of different systems for Pandemics**
- **Provide education and teaching the value of Health, Safety, and Welfare (HSW) as compared with energy impact.**

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Section 1 - Lessons Learned

1. Open Issues

These are the issues that remain unaddressed by COVID-19 guidance as of February 2022.

- **Acceptable Risk Level of a Specific Building -** The current design guide is designed to a core level of protection for an average building, the desired risk level can be different, pending on the location, the type of work, the building design, and the people.

  Location can have impacts to the risk level. Selected locations can have a substantial higher ambient of people infected in the population. Offices located in northern climate in winter can have less amount of air changes compare to summer, so the risk level is higher in winter. Additional measures may be required in the above scenarios to arrive at a lower risk.

  The type of work in the office is also important. If the office is designed to have a lot of people speaking and talking simultaneously, the risk level can be higher. For example, call center, which we saw outbreak in South Korea. If an office has a lunch room, where people will take off their masks and eat with others, the risk level in those spaces can be higher.

  Building design can provide additional path of pathogen transfer. Tall buildings which connect multiple floors with exhaust or plumbing risers can be of concerns since those risers can act as conduits of infectious element transfer. As we saw outbreaks in multiple tall buildings. Other buildings may have atriums etc. that facilitates stack effect and unwanted air movement between floors.

  The occupants have an impact on the virus generation and susceptibility to the virus. More about this below.

  Recommendation: Each office may require assessing the specific risk level, pending on the location, type of work, building design, and people to decide the final proper measures. Also, TC 9.12 should review the impact of both HVAC and plumbing risers to understand more about the potential of pathogen transfer in normal and epidemic times.

- **New COVID-19 Variants and HVAC System Types:** Since the risk level is not linear, new variants with significant higher number of viral loads may not favor systems with lower air changes. See Figure 3[i], comparing VAV system in the summer, which has 5-6 air changes per hour, to a DOAS system with radiant ceiling that has about 1 air changes per hour. While at 10 quanta, the risk level in both systems are relatively low (0.5% versus 1.2%), at 50 quanta, the risk level of DOAS can be significantly higher (1.2% versus 12%). With the Delta and Omicron variants, where the number of viral loads appeared to be significantly higher, DOAS system with low air changes can be riskier[ii].

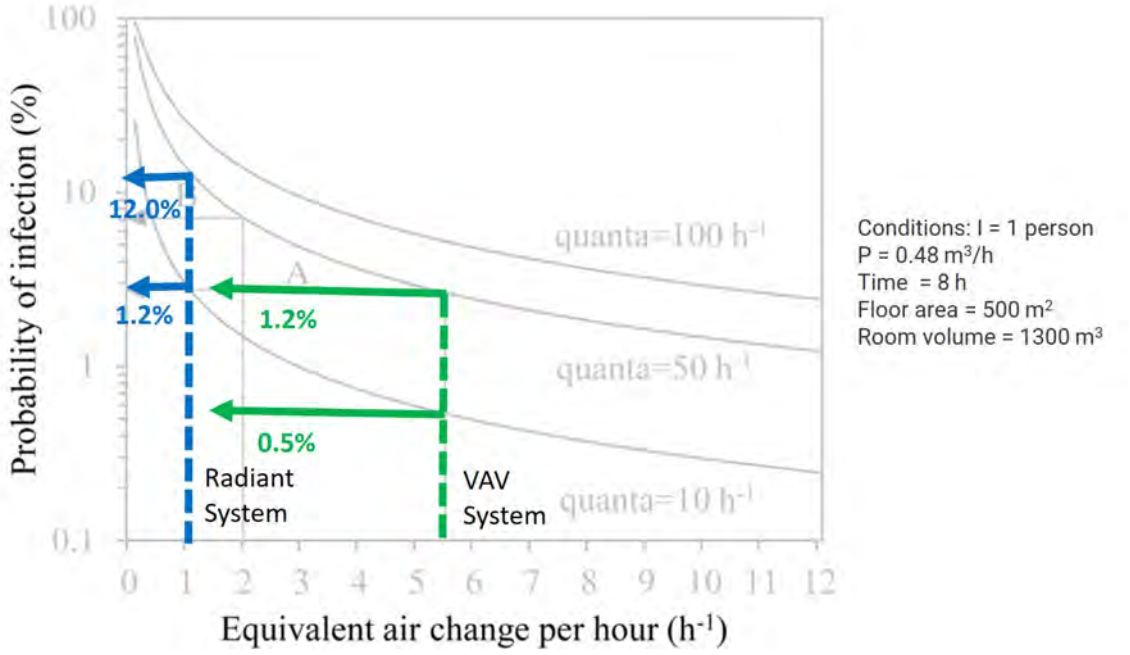

Figure 1: Probability of Infection Between VAV and Radiant System

Recommendation: More research will be required to understand the viral load of the new variants and their relationships with different intrinsic risk levels of systems that have lower air changes in the space.

- **People -** The current design guide is more for an "average" condition in an office the vulnerability of the occupants may not be one size fits all and the amount of infectious virus carries by people can be very different.

  The vulnerability of the occupants is not the same. CDC suggested while age can be an issue, even younger people can be vulnerable, especially if a person is of color and from a working-class family. The measures to protect a person may need to be different pending on their vulnerability[iii].

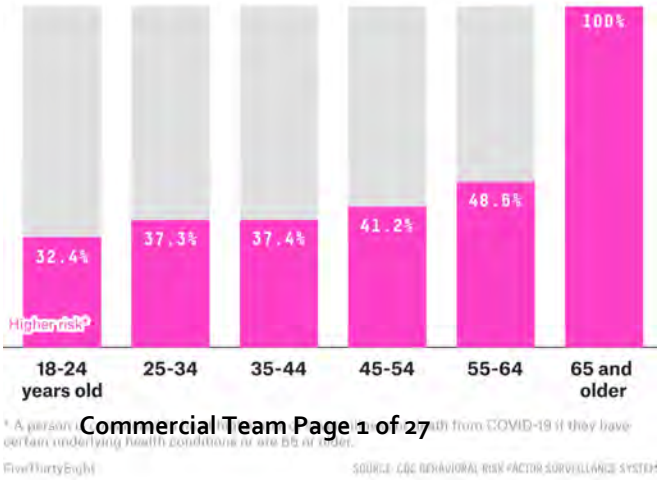

Figure 2: Not Just the Senior Americans Are Vulnerable

The number of infectious particles generated by people is also not the same. Selected research indicated a small percentage of individuals (2%) can carry majority of the virus in the community (90%). Designing for a super-spreader can be different than designing for an "average" infected person[iv].

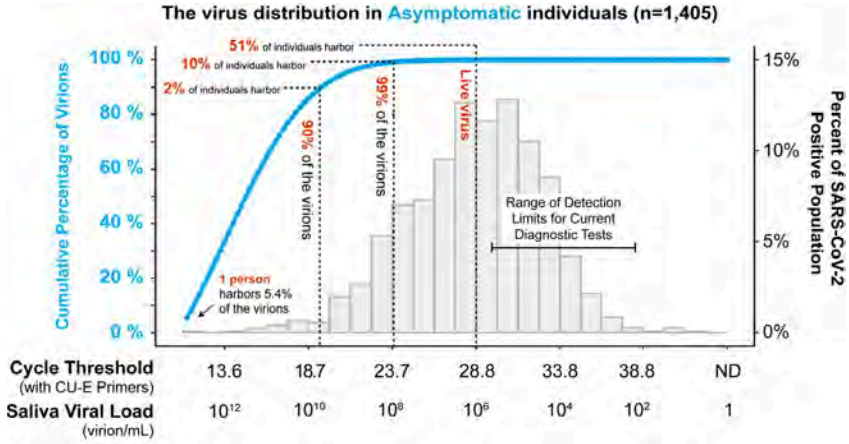

Figure 3: Small Amount of People Can Carry Much of the Virus in a Community

Recommendation: Each office, pending on the type of occupants they have, may require assessing the specific risk level desired, pending on the vulnerability of the population, and whether they are aware if there are super-spreader in their office.

- **Air Flow:**
  - **Underfloor supply systems versus overhead VAV system.** There had been much discussion and confusion during the pandemics about the air quality between underfloor supply systems versus overhead VAV system. While underfloor supply systems in general work with the thermal plume of

humans, there are also multiple articles suggested the resurfacing of the droplets due to underfloor supply and make them not necessarily the system of choice during pandemics.

Recommendation: Have TC 5.3 – Room Air Distribution and/or TC-4.10 – Indoor Environmental Modeling - work on guidance for air distribution impact of underfloor supply systems versus overhead systems.

- **Target Equivalent Outdoor Air quantity required during occupancy for reduced risk during airborne infection emergencies**. Review the recommended equivalent outdoor air quantity for commercial offices.

Recommendation: Since 62.1 is for "Acceptable" IAQ should there be a SPC formed for "Disaster" IAQ to develop the guidance to provide new or temporary targets for various disaster scenarios (flood, hurricanes, wildfires, infectious diseases, etc.). Even if it is a tool for people to put in parameters to get the ACHe or additional CFM/SF of equivalent OA for their situation or CADR.

Design guidance on the impact of room air distribution to reduce the direct transmission of infectious aerosols. It became clear that during this pandemic how air moved through the space has an impact to the infection of the occupants. Also, our assumptions in most engineering tools and practices are based on "well mixed" air within spaces. However, we, as practicing professionals, have little control over the furniture and other obstacle layout and the reality is that most spaces deviate significantly from the well mixed scenario. We need to again sponsor good research on the correction factors that should be used to correct for actual, in place air distribution systems in buildings of all occupancy types.

Recommendation: Have TC 5.3 – Room Air Distribution and/or MTG – Air Change Rate and/or TC-4.10 – Indoor Environmental Modeling - work on guidance for air distribution impact on risk of infection that can be implemented in designs to avoid issues in the next pandemic.

- **Impact of humidity and dirt on MERV rated filters versus MERV-A.** The guidance talks about the use of higher rated MERV filters but does not expand on the impact of using MERV-A versus MERV filters.

Recommendation: Have SPC 52.2 – work on guidance and research to identify the causes and the actual impact of varying RH levels on filters and filter performance prior to use.

- **MERV-13 filter and drop in efficiency especially in pleated 1" filter for fan coil, fan powered boxes, and other terminal devices.** While the guidance suggested the use of MERV-13 filter for recirculated air, there are concerns that the MERV-13 filter efficiency can drop with time, especially the 1" pleated filter that often are MERV-A type filters, which may drop in efficiency faster with time, which the current guides are silent on actual performances. Also, the concerns of filter degradation under UV light.

Recommendation: Have SPC 52.2 – work on guidance and research to identify the filter efficiency drop with time, especially on MERV-A filter and recommend replacement cycles.

- **Impact of Flushing Spaces on Contaminants and Particles**. We did not find information or studies to show the impact of flushing on the space, between occupancies, and the actual reduction in particles over time. This is meant to prove out models of spaces and systems with real world case studies.

Recommendation: Have TC 5.3 – Room Air Distribution and/or MTG – Air Change Rate and/or TC-4.10 – Indoor Environmental Modeling and/or SPC 62.1 work on potential research and the impact of flushing.

- **Furniture, equipment, people, and other indoor objects Impacts:** Furniture, equipment, people, and objects in the space that can create stagnant air with lower air changes. Two types of indoor work station arrangements are studied in Figure 4. A "Pre-pandemic" panel based workstation with full height cubicles, versus Post-pandemic arrangement with partial height panels and different seating configurations. The Post-pandemic arrangement has better mixing and air movement. In any given office space, the supply and return air flow pattern can interact with indoor objects and creates elevated local risk levels. This local risk can be lessened with appropriate local air treatments.

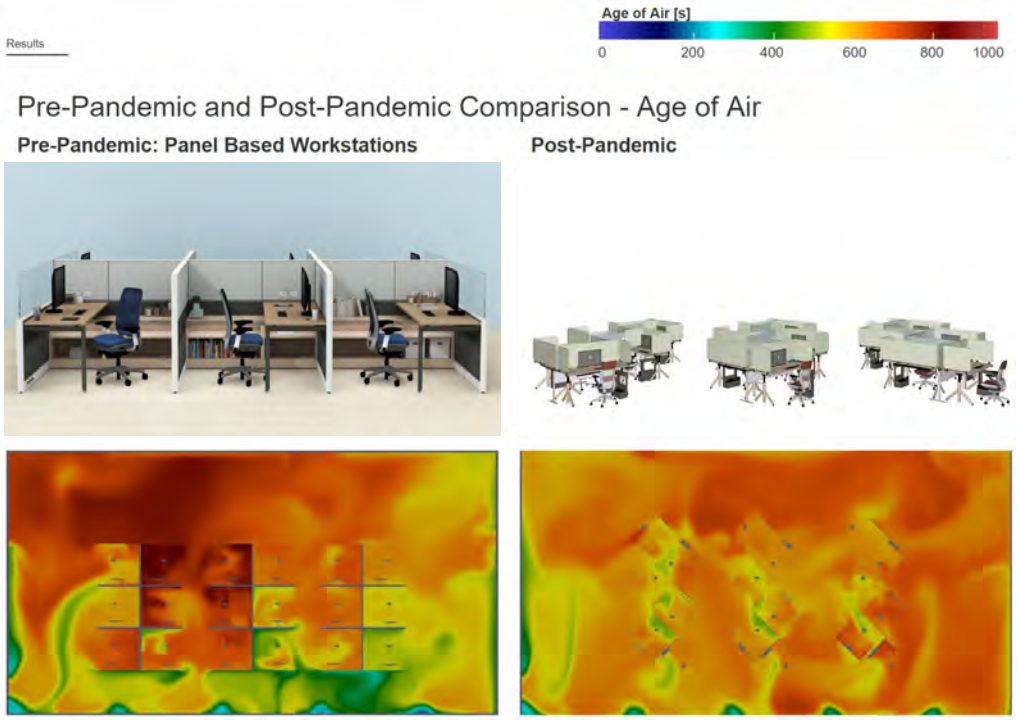

Figure 4: Furniture, Equipment, People, and, Objects Can Create Pockets of Stagnant Air to Elevate Local Risk

- **Actual measurement:** Measurement of actual virus reduction versus the Core Recommendations and equivalent outdoor air approach predictions. The current Equivalent Outdoor Air has approximately 90% as the efficiency of MERV-13 filter in removing COVID-19 material[v]. It will be good to measure whether that is the reality in field conditions. Also, see above regarding how furniture, equipment, people, and objects in an actual office can impact the air flow and prevent the well mixed conditions in an office, the actual flush time to eliminate 95% of the material in a space can be longer, since the local worst case conditions may dictate the time to have 3 air changes.

2. Information for other ASHRAE Groups

What risk reduction guidance generated by this team for COVID-19 should be reviewed by other ASHRAE bodies to see if they believe it should be included in their handbook chapters, guidelines, or standards.

This is organized by ASHRAE committee or group that could potentially evaluate the materials for them to include. The applicable page of the documentation is noted as "# to ##" for the Commercial Guide PDF to indicate the page of interest for that ASHRAE group.

TC 1.4 – Control Theory and Application

- Pages 27 to 28: This deals with the evaluation of an existing controls systems as well as the ability for remote access. It is likely that their documents include this information but might be well to be presented in Epidemic or Disaster Mode of efforts. Also, the idea of "Epidemic Mode" to change the building through a manual switch to the setting.
- Discussions about using CO2 and PM 2.5 etc. as a proxy to measure the infectious risk. Consideration should be given to measure different virus directly. More devices are available to do that currently.

TC 1.12 – Moisture Management in Buildings

- Impact of Increasing Space Relative Humidity in Winter Mode for Reducing COVID-19 Transmission– this guide, in review for publication, covers the evaluation of increasing RH and the impact on the existing building envelope.

TC 2.1 – Physiology and Human Environment

- Pages 15: Deals with the pre- or post- flushing of spaces to reduce contaminants.
- Equivalent Outdoor Air Calculator Tool: This is a practical tool to help determine the impact of the HVAC system for creating "clean air". If we expand such a tool, it should be robust and include a significant number of modifiable inputs for things that can affect and influence a system or device's ability to improve a spaces IAQ and disinfection.

TC 2.3 - Gaseous Air Contaminants and Gas Contaminant Removal Equipment

- Pages 15: Deals with the pre- or post- flushing of spaces to reduce contaminants.

TC 2.4 - Particulate Air Contaminants and Particulate Contaminant Removal Equipment

- Pages 15: Deals with the pre- or post- flushing of spaces to reduce contaminants.
- Pages 15-21: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters.

TC 2.9 – Ultraviolet Air and Surface Treatment

- Page 15, 16, 25: It would be good to have some additional practical application and irradiance levels of UV on infectious aerosols and to have targets for unknown items.
- There are concerns of UV light impact if provide on filter can deteriorate the filter integrity.

TC 2.10 – Resilience and Security

- Entire document should be reviewed to see how it fits their scope.

TC 4.3 – Ventilation Requirements and Infiltration

- Pages 11, 13, 19, 20, 22, 24 28:
- Pre- or post- flushing of spaces to reduce contaminants.
- Equivalent Outdoor Air for flushing of spaces
- Consideration on air movement in elevator lift is important, given the concerns in elevators. Most tall buildings with simple exhaust fan can achieve over 70 air changes, much higher than typical office
- A lot of discussions regarding whether using ceiling fan is healthy. Good to develop guidelines for healthy operations of ceiling fans.

TC 4.4 Building Materials and Building Envelope Performance

- Impact of Increasing Space Relative Humidity in Winter Mode for Reducing COVID-19 Transmission– this guide, in review for publication, covers the evaluation of increasing RH and the impact on the existing building envelope.

TC 5.3 – Room Air Distribution

- Nothing to review as the information for impact of room air distribution with regards to air distribution placement, velocities, and other items impact on infectious aerosols.
- While displacement ventilation may work with the human plume and may have less contaminants in the space, there have been also researches indicate the among droplets can be resurface by displacement ventilation during pandemic. Helpful to understand more about ten resurface of droplets in future research.

TC 5.5 – Air-to-Air Energy Recovery

- Page 17: Deals with whether to use recovery devices.

TC 6.6 – Service Water Heating Systems

- Pages 23: hot water system temperatures.

TC 7.3 – Operation, Maintenance and Cost Management

- Pages 15 to 26: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters.
- Different studies indicated out of 4 strategies of increase outside air, MERV-13 filter, UV light, and portable air cleaner, the lowest first and operating cost method to achieve MERV-13 filter equivalent performance is simply use MERV-13 filter. Additional studies to confirm the findings will be helpful
- Concerns about pleated MERV-13 filter is not as durable and require more frequent changes
- Different studies indicated MERV-13 filter does necessarily increases static pressure and as a result operational cost increases.

TC 7.7 – Testing and Balancing

- Pages 19: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters that TAB might want to explain the approach on how to do this effort.
- MERV-13 filter rating can be quickly deteriorated with leakages around the filter frame racks. How to test the actual performance of MERV-13 filter did not deteriorate through leakages around the filter frames?

TC 7.8 – Owning and Operating Costs

- Pages 15-26: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters. Doing this work without increasing operating cost is big.
- Different studies indicated out of 4 strategies of increase outside air, MERV-13 filter, UV light, and portable air cleaner, the lowest first and operating cost method to achieve MERV-13 filter equivalent performance is simply use MERV-13 filter. Additional studies to confirm the findings will be helpful
- Concerns about pleated MERV-13 filter is not as durable and require more frequent changes
- Different studies indicated MERV-13 filter does necessarily increases static pressure and as a result operational cost increases.
- Use of Equivalent Outdoor Air approach to minimize the flushing time required in achieving 3 air changes.

TC 7.9 – Building Commissioning

- Pages 19: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters that TAB might want to explain the approach on how to do this effort.
- MERV-13 filter rating can be quickly deteriorated with leakages around the filter frame racks. How to test the actual performance of MERV-13 filter did not deteriorate through leakages around the filter frames?
- How do we think about commissioning buildings for pandemic rather than for energy?

TC 9.1 – Large Building Air-Conditioning Systems (S&E Chapter 4)

- Pages 15-26: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters.
- Current Core Recommendations requested recirculation air to be MERV-13 or better. How do we do that in fan coil units, fan powered boxes, VRF, chilled beam etc. systems that have local recirculation?
- Certain high efficiencies systems, e.g. DOAS with radiant ceiling, can have very low air changes for just outside air. These low air changes system can face exponential increases in infection risk when the virus load is high (refer to **"COVID-19 Variants and HVAC System Types"** on page 1
- While Under Floor Air Distribution and Displacement Ventilation are known to work with the thermal plume of humans to provide better indoor air quality, it is less certain whether that is working with infectious diseases that have much infectious droplets. Selected research suggested the risk of resurfacing of material.

TC 9.8 – Large Building Air-Conditioning Applications

- Pages 15-26: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters.
- Current Core Recommendations requested recirculation air to be MERV-13 or better. How do we do that in fan coil units, fan powered boxes, VRF, chilled beam etc. systems that have local recirculation?
- Certain high efficiencies systems, e.g. DOAS with radiant ceiling, can have very low air changes for just outside air. These low air changes system can face exponential increases in infection risk when the virus load is high (refer to **"COVID-19 Variants and HVAC System Types"** on page 1
- While Under Floor Air Distribution and Displacement Ventilation are known to work with the thermal plume of humans to provide better indoor air quality, it is less certain whether that is working with infectious diseases that have much infectious droplets. Selected research suggested the risk of resurfacing of material.

TC 9.12 – Tall Buildings

- Pages 14, 25: This talks about the impact of the stack effect. It is unclear the impact of stack effect impact to spread of virus in tall building.
- There have been multiple studies indicated in both air and water risers, stack effect in combination with the design of the air of water riser can help spread the virus. Further studies should be performed to understand the mitigation strategies.
- Multiple tall buildings around the world had encountered outbreaks, more studied will be required to understand the reasons and mitigation measures.

SPC 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

- Page 13,15,16,19, 20, 21, 22, 24, 25: General information on filters. Need to expand MERV-A discussion.

SSPC 62.1 – Ventilation for Acceptable Indoor Air Quality

- Pages 14, 15: Deals with the pre- or post- flushing of spaces to reduce contaminants.
- Equivalent Outdoor Air for flushing of spaces
- Considerations in making provisions for all future commercial new buildings and renovations to make MERV-13 filter provisions or capable. Should this be extended to fan coil units, fan powered boxed, VRF etc. terminal units? Current Core Recommendations suggested MERV-13 filter minimum for recirculation

SPC 160-2016 -- Criteria for Moisture-Control Design Analysis in Buildings

- Impact of Increasing Space Relative Humidity in Winter Mode for Reducing COVID-19 Transmission– this guide, in review for publication, covers the evaluation of increasing RH and the impact on the existing building envelope.

SPC 180-2018: Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems

- Pages 15 to 26: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters.
- MERV-13 filter rating can be quickly deteriorated with leakages around the filter frame racks. How to test the actual performance of MERV-13 filter did not deteriorate through leakages around the filter frames?
- How do we think about inspection of buildings for pandemic rather than for energy?

SPC 188-2018: Legionellosis: Risk Management for Building Water Systems

- Pages 23: hot water system temperatures.

SSPC 300 Building Commissioning

- Pages 19: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters that TAB might want to explain the approach on how to do this effort.
- MERV-13 filter rating can be quickly deteriorated with leakages around the filter frame racks. How to test the actual performance of MERV-13 filter did not deteriorate through leakages around the filter frames?
- How do we think about commissioning buildings for pandemic rather than for energy?
- How do we commission the "pandemic mode" operations in BAS?

GPC 12-2020 - Managing the Risk of Legionellosis Associated with Building Water Systems

- Pages 23: hot water system temperatures.

GPC 36-2021 - High-Performance Sequences of Operation for HVAC Systems

- Pages 15-26: This talks about the impact of the increase in filter efficiency in pandemic mode. There is an evaluation that can be done between existing and higher MERV filters.
- Current Core Recommendations requested recirculation air to be MERV-13 or better. How do we do that in fan coil units, fan powered boxes, VRF, chilled beam etc. systems that have local recirculation?
- Certain high efficiencies systems, e.g. DOAS with radiant ceiling, can have very low air changes for just outside air. These low air changes system can face exponential increases in infection risk when the virus load is high (refer to **"COVID-19 Variants and HVAC System Types"** on page 1.
- While Under Floor Air Distribution and Displacement Ventilation are known to work with the thermal plume of humans to provide better indoor air quality, it is less certain whether that is working with infectious diseases that have much infectious droplets. Selected research suggested the risk of resurfacing of material.

MTG.ACR – Air Change Rate

- Pages 15-26: Use of Equivalent Outdoor Air approach for flushing 3 air changes
- Certain high efficiencies systems, e.g. DOAS with radiant ceiling, can have very low air changes for just outside air. These low air changes system can face exponential

increases in infection risk when the virus load is high (refer to **"COVID-19 Variants and HVAC System Types"** on page 1

- While Under Floor Air Distribution and Displacement Ventilation are known to work with the thermal plume of humans to provide better indoor air quality, it is less certain whether that is helpful with infectious diseases that have much infectious droplets. Selected research suggested the risk of resurfacing of material, especially higher air changes system similar to UFAD

MTG.EBO – Effective Building Operations

- Pages 15-26: Use of Equivalent Outdoor Air approach for flushing 3 air changes
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- MERV-13 filter rating can be quickly deteriorated with leakages around the filter frame racks. How to test the actual performance of MERV-13 filter did not deteriorate through leakages around the filter frames?
- How do we think about inspection of buildings for pandemic rather than for energy?

MTG.HWBE – Health and Wellness in the Built Environment

- Pages 15-26: Use of Equivalent Outdoor Air approach for flushing 3 air changes
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- How do we think about inspection of buildings for pandemic rather than for energy?

- Indoor objects, e.g. furniture, equipment, people, etc. can impact ventilation effectiveness both in normal and pandemic times. How do we address the local conditions?

3. Issues Beyond this Guidance

Issues outside this team's assigned responsibilities that affect the effectiveness of ASHRAE's pandemic response.

To improve epidemic response, the ASHRAE Board of Directors may wish to consider these observations and suggestions:

- **Develop a Generation of Healthier Buildings Against Holistic of Air Quality Threats:** From wild fire, to infectious diseases, to high ambient of PM 2.5 material in the air, there are a holistic threat of air quality issues to humanity. Regarding commercial buildings, it is clear through the pandemic experience that majority of the commercial buildings can replace their current filter with MERV-13 with little material impacts. However, that is not the case in other building types, e.g. senior living., which many have HVAC system that cannot insert MERV-13 filter, e.g. selected VRF indoor cassettes. The current standard is deficient regarding filtering and the result is significant outbreaks in those building typologies. Wild fire is another health threat regarding air quality. ASHRAE Planning Framework for Protecting Commercial Building Occupants from Smoke During Wildfire Events suggested the use of MERV-13 filter. (https://www.ashrae.org/File%20Library/Technical%20Resources/COVID-19/Planning-Framework-for-Protecting-Commercial-Building-Occupants-from-Smoke-During-Wildfire-Events.pdf). Many cities around the world have high level of PM 2.5, the latest version of UN WHO health standard suggested a lower level of PM 2.5 to 5 ug/M^3 annual average and 10 ug/ M^3 24 hours' average. (https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)

  Recommendation: To deliver a new generation of healthier buildings against future air quality threats, ASHRAE should make MERV-13 filter the minimum requirement "capable" in new buildings and existing building that will be undergoing renovation in HVAC systems. While during times when air quality is good, one can use lower MERV rating filters, buildings should be able to operate with MERV-13 filters when required. This should be changed immediately with EHC, 62.1, 62.2 and other relevant committees working together.

- **Develop New Standards**
  - **Develop a New Indoor Environment Quality Standard and Audit Document:** Currently we have energy audit standards, and selected auditing guides that includes indoor air quality. We do not have standards on holistic Indoor Environmental Quality Audit. During pandemics, commercial building owners and operators were looking for a document to see if they are ready for health and wellness. There have been observations in office buildings that outside air dampers are not opening enough, to discussions about filter racks have gaps

around the framing that will decrease the MERV ratings. Standard 211- 2018, *Standard for Commercial Building Energy Audits* (ANSI Approved/ACCA Co-sponsored) is about energy, Standard 180-2018 -- *Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems* (ANSI Approved; ACCA Co-sponsored), establishes minimum HVAC inspection and maintenance requirements that preserve a system's ability to achieve acceptable thermal comfort, energy efficiency, and indoor air quality in new and existing commercial buildings. There are no holistic "Health and Wellness" audits like energy audit that are applicable to commercial office for holistic indoor environment.

Recommendation: Deliver a Work Place Health and Wellness Standard and Audit document. A MTG can be formed to work on this. Post pandemic work places are looking at holistic Indoor Environmental Quality rather than just Indoor Air Quality. This document should consider health and wellness both in normal times and times with abnormal event

- **Develop method of test for air cleaning devices like Std 185 for UV.** Existing systems fall out of calibration and control over time impacting energy and IEQ. Concerns of dropping efficiencies in MERV-A filters with time, etc. In addition, existing buildings may lack the IAQ measuring components that are being recommended due to this pandemic.

Recommendation: ASHRAE needs solid research and independent third-party evaluations of all new and existing air cleaning technologies and method of test standards to rapidly test any emerging technologies and new disaster scenarios present themselves in the future.

- **Develop Dynamic Thermal Research and Guidelines:** From the use of operable window, to semi outdoor space, to outdoor dining, etc., there have been emerging interest in half climate spaces that are semi open, or entirely open, to outdoors.

  Recommendation: Environmental Health Committee should start reviewing the dynamic thermal environments to understand the holistic impacts to thermal comfort, health, and wellness etc.

- **Develop research in actual field performances of different systems in pandemics.** The industry has limited data on actual field study of how different mitigation strategies perform in real operational settings. While Equivalent Outdoor Air approach provide approximation, it will be good to measure the results in actual settings. There are also unknowns in the actual performances of underfloor supply systems compares to overhead VAV during pandemics.

  Recommendation:

Research should be solicited regarding the actual performances of MERV-13 filter in real world setting with virus and different HVAC systems in office environment.

- **Provide guidance and teaching the value of Health, Safety, and Welfare (HSW) as compared with energy impact.** While energy efficiency is important, we should spend some time educating the public on the importance of HVAC systems on the health, safety, and welfare (HSW) of building occupants and that systems should provide for HSW first and be as efficient as possible while satisfying the basic HSW requirements.

  Recommendation:

  Have the Environmental Health Committee work with other ASHRAE Technical Groups to develop training on the impact of HSW and energy. This could be applicable to the common systems found in buildings and the optimization measures people are using to reduce energy.

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Section 2 – List of Team-Generated Guidance

This team has developed the following text, graphics, and tools that ASHRAE standing and technical committees may wish to consider when developing more durable, long-term standards and guidance:

Primary Author:

- **Commercial guidance main page**

  https://www.ashrae.org/technical-resources/commercial

Assisted:

- **In-Room Air Cleaner Guidance for Reducing Covid-19 In Air in Your Space/Room**
  https://www.ashrae.org/file%20library/technical%20resources/covid-19/in-room-air-cleaner-guidance-for-reducing-covid-19-in-air-in-your-space-or-room.pdf
- **Guidance For Polling Place HVAC Systems**
  https://www.ashrae.org/file%20library/technical%20resources/covid-19/guidance-for-polling-place-hvac-systems.pdf
- **Environmental Health Emerging Issue Brief**
  https://www.ashrae.org/file%20library/technical%20resources/covid-19/eiband-airbornetransmission.pdf
- **Communities of Faith Guidance**
  https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-communities-of-faith-c19-guidance.pdf
- **Building Readiness Guidance**
  https://www.ashrae.org/technical-resources/building-readiness
- **Frequently asked questions and answers for re-opening or shuttering buildings**

Section 3 – Technical References

ASHRAE standards, handbook chapters or special publications that team members found helpful for advising the public and developing residential COVID guidance.

The following is a listing of ASHRAE documents and non-ASHRAE documents that were used in building the guidance of this team. There are notes as to the importance of these documents to the guidance.

The following ASHRAE documents were used to help build the guidance documents:

- "Study of Viral Filtration Performance of Residential HVAC Filters", John Zhang, Doug, Huntley, Andy Fox, Bryan Gerhardt, Al Vatine, John Cherne, ASHRAE Journal, August 2020
- ASHRAE Standard 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
  - Impact of filter ratings and droplet nuclei capture efficiency.
- ASHRAE Standards 62.1 – Ventilation for Acceptable Indoor Air Quality
  - Table 6-4 – for room air distribution effectiveness
  - For Code minimum OA requirements using the standard's prescriptive tables
- ASHRAE Standard 111-2008 (RA 2017) - Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation and Air-Conditioning Systems
  - For evaluation of existing systems and the importance of proper TAB
- ASHRAE Standard 180-2018: Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems
  - Impact of how systems can be maintained, or not, by facilities to improve their performance before the next pandemic
  - Developing checklists for the inspection of existing HVAC systems with a focus toward their ability to provide adequate filtration, ventilation, and, if necessary, air cleaning, with respect to mitigating the spread of infectious aerosols and particulates.
- ASHRAE Standard 188-2018: Legionellosis: Risk Management for Building Water Systems
  - Water quality impact of shuttering a building and re-opening
- ASHRAE Guideline 1.4-2019: Preparing Systems Manuals for Facilities
  - Proper method to document systems operation for pandemic modes
- Guideline 12-2020 - Managing the Risk of Legionellosis Associated with Building Water Systems
  - Water quality impact of shuttering a building and re-opening

- ASHRAE Guideline 36-2018 - High-Performance Sequences of Operation for HVAC Systems
  - Methods of control for systems that could be adopted to reduce energy during a pandemic
- 2019 ASHRAE Handbook—APPLICATIONS - Chapter 62 - Ultraviolet air and surface treatment
  - UV guidance for inactivating viruses and bacteria
- 2020 ASHRAE Handbook – HVAC Systems and Equipment – Chapter 26 – Air-to-Air Energy Recovery Equipment
  - Understanding of energy recovery wheels and thermal plates potential impact on air quality
- 2016 ASHRAE Handbook – HVAC Systems and Equipment – Chapter 17 – Ultraviolet Lamp Systems
  - UV guidance for inactivating viruses and bacteria
- ASHRAE RP-1088 titled Coordinate and Analyze Interlaboratory Testing of Filters under ASHRAE Standard 52.2 to Determine the Adequacy of the Apparatus Qualification Tests dated May 12, 2005, completed by RTI International
  - Impact of filter ratings and the capture droplet nuclei efficiency.

- ASHRAE Design Guide for Tall, Supertall, and Megatall Building Systems, Second Edition
  - Impact of stack effect, and riser connection

- ASHRAE 2019 Application – Tall Buildings
  - Impact of stack effect, and riser connection
- ETF Core Recommendations
- Filtration and Disinfection Guidance
- ETF Exhaust Air Reentrainment Guide
- ETF Building Readiness
- ETF Practical Guidance for Epidemic Operations of Energy Recovery Ventilation Systems
  - Authored by TC 5-5 (Air-to-Air Energy Recovery) and Building Readiness Team
- ASHRAE Position Document on Infectious Aerosols
- ASHRAE Position Document on Filtration and Air Cleaning
- ASHRAE Journal article: Ultraviolet Germicidal Irradiation - Current Best Practices (2008, Martin et al)

- UV guidance for inactivating virus and bacteria

The following items are non-ASHRAE Publications that were used in the development of this document:

- COVID-19 Employer Information for Office Buildings
  https://www.cdc.gov/coronavirus/2019-ncov/community/office-buildings.html
  Office building guidelines

- OSHA Guidance on Preparing Work Places for COVID-19
  https://www.osha.gov/Publications/OSHA3990.pdf
  Office building guidelines

- EPA Reducing Airborne Transmission of COVID-19
  https://www.epa.gov/coronavirus
  General information

- REHVA COVID-19 Guidance
  https://www.rehva.eu/activities/covid-19-guidance
  Office building guidelines

- IEQ-GA AiCARR's Position on HVAC System Operation During SARS-COVID-19 Emergency
  https://ieq-ga.net/2020/04/aicarrs-position-on-hvac-system-operation-during-sars-covid-19-emergency/
  General information

- UN WHO Roadmap to improve and ensure good indoor ventilation in the context of COVID-19
  https://www.who.int/publications/i/item/9789240021280
  General information

- Estimated Airborne Decay of SARS-coV2
  https://www.dhs.gov/science-and-technology/sars-airborne-calculator

- Estimated Surface Decay of SARS-coV2
  https://www.dhs.gov/science-and-technology/sars-calculator

- NIST - FaTIMA
  https://www.nist.gov/services-resources/software/fatima

- "Coronavirus Disease Outbreak in Call Center, South Korea"
  Shin Young Park, Young-Man Kim, Seonju Yi, Sangeun Lee, Baeg-Ju Na, Chang Bo Kim, Jung-Il Kim, Hea Sook Kim, Young Bok Kim, Yoojin Park, In Sil Huh, Hye Kyung Kim, Hyung Jun Yoon, Hanaram Jang, Kyungnam Kim, Yeonhwa Chang, Inhye Kim, Hyeyoung Lee, Jin Gwack, Seong Sun Kim, Miyoung Kim, Sanghui Kweon, Young June Choe, Ok Park, Young Joon Park, Eun Kyeong Jeong, Emerg Infect Dis. 2020 Aug; 26(8): 1666–1670.,doi: 10.3201/eid2608.201274
  Virus spread in office environment

- "Possible aerosol transmission of COVID-19 associated with an outbreak in an apartment in Seoul, South Korea, 2020"
  Seo EunHwang, Je HwanChang, BumjoOh,
  ,https://doi.org/10.1016/j.ijid.2020.12.035

- "COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China, 2020"
  Jianyun Lu, Jieni Gu, Kuibiao Li, Conghui Xu, Wenzhe Su, Zhisheng Lai, Deqian Zhou, Chao Yu, Bin Xu, and Zhicong Yang
  Emerg Infect Dis. 2020 Jul;26(7):1628-1631., doi: 10.3201/eid2607.200764. Epub 2020 Apr 2.

- "Environmental factors involved in SARS-CoV-2 transmission: effect and role of indoor environmental quality in the strategy for COVID-19 infection control", Kenichi Azuma, U Yanagi, Naoki Kagi, Hoon Kim, Masayuki Ogata & Motoya Hayashi, Environmental Health and Preventive Medicine, volume 25,
  Article number: 66 (2020)

- "The reproductive number of the Delta variant of SARS-CoV-2 is far higher compared to the ancestral SARS-CoV-2 virus**"**, Ying Liu, Joacim Rocklöv, Journal of Travel Medicine, Volume 28, Issue 7, October 2021,
  taab124, https://doi.org/10.1093/jtm/taab124

- "HVAC filtration for controlling infectious airborne disease transmission in indoor environments: Predicting risk reductions and operational costs," P. Azimi and B. Stephens, 04 09 2013. [Online]. Available:
  https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7127325

- "Probable airborne transmission of SARS-CoV-2 in a poorly ventilated restaurant" Yuguo Li, Hua Qian, Jian Hang, Xuguang Chen, Pan Cheng, Hong Ling, Shengqi Wang, Peng Liang, Jiansen Li, Shenglan Xiao, Jianjian Wei, Li Liu, Benjamin J. Cowling, Min Kang
  https://doi.org/10.1016/j.buildenv.2021.107788

- "Identification of SARS-CoV-2 RNA in Healthcare Heating, Ventilation, and Air Conditioning Units", Patrick F. Horve, Leslie Dietz**,** Mark Fretz, David A. Constant, Andrew Wilkes, John M. Townes, Robert G. Martindale, William B. Messer, Kevin G. Van Den, Wymelenberg, **doi:** https://doi.org/10.1101/2020.06.26.20141085, *Indoor Air* doi: 10.1111/ina.12898

- "Mechanistic Transmission Modeling of COVID-19 on the Diamond Princess Cruise Ship Demonstrates the Importance of Aerosol Transmission", Azimi, Zahra Keshavarz, Jose Guillermo Cedeno Laurent, Brent R. Stephens, Joseph G. Allen,
  doi: https://doi.org/10.1101/2020.07.13.20153049, *Proceedings of the National Academy of Sciences* doi: 10.1073/pnas.2015482118

- "Long-distance airborne dispersal of SARS-CoV-2 in COVID-19 wards", Karolina, Nissen Uppsala University, Janina Krambrich Uppsala University, Dario Akaberi Uppsala University, Tove Hoffman Uppsala University, Jiaxin Ling Uppsala

University, Åke Lundkvist Uppsala University, Erik Salaneck (à erik.salaneck@medsci.uu.se) Uppsala University, PMID: 33177563, PMCID: PMC7659316, DOI: 10.1038/s41598-020-76442-2

- "Aerosol and surface contamination of SARS-CoV-2 observed in quarantine and isolation care" Joshua L. Santarpia, Danielle N. Rivera, Vicki L. Herrera, M. Jane Morwitzer, Hannah M. Creager, George W. Santarpia, Kevin K. Crown, David M. Brett-Major, Elizabeth R. Schnaubelt, M. Jana Broadhurst, James V. Lawler, St. Patrick Reid & John J. Lowe, https://pubmed.ncbi.nlm.nih.gov/32728118/

- "Detection of air and surface contamination by SARS-CoV-2 in hospital rooms of infected patients", Po Ying Chia , Kristen Kelli Coleman, Yian Kim Tan, Sean Wei Xiang Ong, Marcus Gum, Sok Kiang Lau, Xiao Fang Lim, Ai Sim Lim, Stephanie Sutjipto, Pei Hua Lee, Than The Son, Barnaby Edward Young, Donald K Milton, Gregory C Gray, Stephan Schuster, Timothy Barkham, Partha Pratim De, Shawn Vasoo, Monica Chan, Brenda Sze Peng Ang, Boon Huan Tan, Yee-Sin Leo, Oon-Tek Ng, Michelle Su Yen Wong, Kalisvar Marimuthu, Singapore 2019 Novel Coronavirus Outbreak Research Team, PMID: 32472043, PMCID: PMC7260225, DOI: 10.1038/s41467-020-16670-2

- "Viable SARS-CoV-2 in the air of a hospital room with COVID-19 patients", John A. Lednicky, Michael Lauzardo, Z. Hugh Fan, Antarpreet Jutla, Trevor B. Tilly, Mayank Gangwar, Moiz Usmani, Sripriya Nannu Shankar, Karim Mohamed, Arantza Eiguren-Fernandez, Caroline J. Stephenson, Md. Mahbubul Alam, Maha A. Elbadry, Julia C. Loeb, Kuttinchantran Subramaniam, Thomas B. Waltzek, Kartikeya Cherabuddi, J. Glenn Morris, Jr., and Chang-Yu Wu, PhD, https://pubmed.ncbi.nlm.nih.gov/32793914/

- https://www.volkskrant.nl/nieuws-achtergrond/vertrouwelijk-rivm-rapport-ventilatiesysteem-verspreidde-virus-in-verpleeghuis~bdc4943d

- COVID-19 Airborne Transmission Tool Available https://cires.colorado.edu/news/covid-19-airborne-transmission-tool-available

- AHAM. 2015. "ANSI/AHAM AC-1-2015, Method for Measuring Performance of Portable Household Electric Room Air Cleaners." Association of Household Appliance Manufacturers.
  - In room air cleaner performance
- NIOSH Guidelines – 2009
  - Hierarchy of controls
- American Water Works Association (AWWA) - Shutoffs and Return to Service Guidance (https://www.awwa.org/Resources-Tools/Resource-Topics/Coronavirus#10681543-shutoffs-and-return-to-service-guidance)
  - Water quality for shuttering and re-opening buildings

[i] Kenichi Azuma, U Yanagi, Naoki Kagi, Hoon Kim, Masayuki Ogata & Motoya Hayashi
"Environmental factors involved in SARS-CoV-2 transmission: effect and role of indoor environmental quality in the strategy for COVID-19 infection control"
Environmental Health and Preventive Medicine, volume 25, Article number: 66 (2020)

[ii] Ying Liu, Joacim Rocklöv, "The reproductive number of the Delta variant of SARS-CoV-2 is far higher compared to the ancestral SARS-CoV-2 virus", *Journal of Travel Medicine*, Volume 28, Issue 7, October 2021, taab124, https://doi.org/10.1093/jtm/taab124

[iii] https://fivethirtyeight.com/features/the-young-americans-most-vulnerable-to-covid-19-are-people-of-color-and-the-working-class/

[iv] Qing Yang, et al, "Just 2% of SARS-CoV-2–positive individuals carry 90% of the virus circulating in communities", PNAS May 25, 2021 118 (21) e2104547118; https://doi.org/10.1073/pnas.2104547118

[v] https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-building-readiness.pdf

Appendix C - ETF Roster and Volunteers PDF

Team Members/Contributors	Employer
Epidemic Task Force	
Bill Bahnfleth (Chair, External Organizations Lead)	Penn. State University
Dennis Knight (Vice-Chair, Communications Team Lead)	Whole Building Systems
Brad Cochran (Laboratories Team Lead)	CPP Wind
Corey Metzger (Schools Team Lead)	Resource Consulting Engineers
Jason DeGraw (Transportation Team Lead)	ORNL
John McKernan (Industrial Team Lead)	US Environmental Protection Agency
Luke Leung (Commercial/Retail Team lead & EHC liaison)	Skidmore Owings & Merrill (SOM)
Max Sherman (Residential Team Lead)	Lawrence Berkeley Laboratory
Pawel Wargocki (Applications Team Lead)	Technical University of Denmark
Rick Hermans (Research Team Lead)	Retired
Stephanie Taylor (Literature Review/Scientific Background Team)	Taylor Healthcare Consulting
Steve Martin (Filtration and Disinfection Team Lead)	NIOSH
Traci Hanegan (Healthcare Team Lead)	Coffman Engineers
Wade Conlan (Resource Inventory & Building Readiness Team Lead)	Hanson Professional Services
Walid Chakroun (Developing Economies Team Lead)	Kuwait University
Jim Ridenhour* (Consultant)	Fluor
Tim McGinn* (BOD liaison)	McGinn Technical Services
Mike Pouchak* (RAC liaison)	Honeywell
Rick Heiden* (STDS liaison)	The Trane Company
Larry Smith* (TAC liaison)	Linx Industries
Chad Smith* (GAC liaison)	Airetech Corporation
Alice Yates*	ASHRAE
Stephanie Reiniche*	ASHRAE
Steve Hammerling*	ASHRAE
Vanita Gupta*	ASHRAE
**designates non-voting member of ETF*	
Communications Team	
Dennis Knight	Whole Building Systems
Alice Yates	ASHRAE
Bill Bahnfleth	Penn. State University
Jeff Littleton	ASHRAE
Stephanie Reiniche	ASHRAE
Steve Hammerling	ASHRAE
Vanita Gupta	ASHRAE
Healthcare Team	
Traci Hanegan	Coffman Engineers
David Eldridge	Grumman/Butkus Associates
Eric Granzow	Specialized Engineering Solutions
Frank Mills	Frank Mills Consulting
Jeremy Fauber	HEAPY
Jerry Ivey	Willis-Knighton Health System
Jonathan Flannery	ASHE
Kathleen Owen	Owen Air Flitration Consulting
Kishor Khankari	Ansight
Laurence Wilson	WSP
Melvin Glass	EMC Engineers
Michael Sheerin	TLC Engineering Solutions
Mike Cummiskey	Virginia Dept. of Health / Dental Division
Mike Meteyer	Erdman

Paul Supan	American Dental Association Volunteer
Rick Hermans	Retired
Robert Block	Dr. Robert M. Block, DDS
Roger Lautz	Affiliated Engineers Inc. (AEI)
Steven Welty	Green Clean Air
Tim Earhart	McDonough Bolyard Peck
Wayne Stoppelmoor	Schneider Electric
Zaccary Poots	Toro-Aire Inc
Residential Team	
Max Sherman	Lawrence Berkeley Laboratory
Brent Stephens	Illinois Institute of Technology
Chandra Sekhar	National University of Singapore
Iain Walker	Lawrence Berkeley Laboratory
Lew Harriman	Mason Grant
Rick Karg	Residential Energy Dynamics
Simon Pallin	Oak Ridge National Laboratory
Steve Emmerich	National Institute of Standards and Technology
Valerie Leprince	PLEIAQ
Commercial, Retail Team	
Luke Leung	Skidmore Owings & Merrill (SOM)
Amy Jiron	US DOE
Bill Livingood	NREL
Brian Gilligan	GSA
Charles Funk	Jacobs
Christian Callaghan	WeWork
Jennifer Isenbeck	Sodexo – Univ. of Tampa Facilities
Josephine Lau	University of Nebraska Lincoln
Marcus Bianchi	NREL
Marwa Zaatari	enVerid Systems
Nicholas Rajkovich	State University of New York at Buffalo
Stephen Ray	Skidmore Owings & Merrill (SOM)
Paul Torcellini	NREL
Peter Simmonds	Building and Systems Analytics
Schools Team	
Corey Metzger	Resource Consulting Engineers
Bruce Lindsay	Brevard Public Schools
Chris Ruch	National Energy Management Institute
Chuck Kovac	Daikin Applied
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Dennis Knight	Whole Building Systems
Eric Haley	Baskervill
Frank Mills	Frank Mills Consulting
Itzak Maor	Smart Buildings Technology
John Nix	John Nix Consulting
Julia Keen	Kansas State University
Keith Hammelman	Cannon Design
Kyle Hasenkox	Rocky Point Engineering
Raj Kapoor	Star Consultants Inc.
Raj Setty	Setty and Associates International
Rick Hermans	retired
Transportation Team	

Jason DeGraw	ORNL
Augusto San Cristobal	Bronswerk Marine
Byron Jones	Kansas State University
Donald LeBlanc	National Research Council Canada
Haven Cassidy	Denver International Airport
Jim Bushnell	HVAC Consulting Services
Building Readiness Team	
Wade Conlan	Hanson Professional Services
Brad Cochran	CPP Wind
Dennis Knight	Whole Building Systems
Duncan Phillips	RWDI
Heather Platt	Dewberry
Jim Ridenhour	Retired
John Hamilton	TABB
Jon Sheppard	Atlantic Testing
Joseph Deringer	Institute for the Sustainable Performance of Buildings)
Justin Garner	Engineered Air Balance Co., Inc.
Kent Walters	Control Management, Inc.
Megan Sterl	Montana State University - Bozeman
Michael Craig	RWDI
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Tiffany Suite (corresponding)	NEBB
Tom Smith	3FLow
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Steve Martin	NIOSH
Bill Bahnfleth	Penn. State University
Dean Saputa	UV Resources
Edward Nardell	Harvard Medical School
Jason DeGraw	ORNL
Kathleen Owen	Owen Air Filtration Company
Matthew Middlebrooks	Filtration Group HVAC
Sam Guzman	American Ultraviolet Company
Steven Welty	Green Clean Air
Wane Baker	Trane
Developing Economies Team	
Walid Chakroun	Kuwait University
Alice Yates	ASHRAE
Resource Inventory Team (retired)	
Wade Conlan	Hanson Professional Services
Becca Coalson	ecoPreserve. LLC
Imane El Ghazouani	Hanson Professional Services
Jason Alphonso	
Jennifer Leach	United Energy Products
Jon Cohen	ChemTreat
Mat Coalson	Hanson Professional Services

Literature Review/Scientific Background Team	
Stephanie Taylor	Taylor Healthcare Consulting
Pawel Wargocki	Technical University of Denmark
Steve Martin	NIOSH
Laboratories Team	
Brad Cochran	CPP Wind
Adam Bare	Newcomb & Boyd
Guy Perrault	
James Coogan	Siemens
Jason Atkisson	AEI
John Castelvecchia	Shultz & James, Inc.
Kevin Belusa	Airgenuity
Kishor Khankari	Ansight
Lisa Churchill Dickerson	Arup
Robert Weidner	Gannet Flemming
Thomas Smith	3Flow
Vince Sakraida	Skanska
Wade Conlan	Hanson Professional Services
Yvon Lachance	BGLA
Industrial Team	
John McKernan	US Environmental Protection Agency
Duncan Phyfe	Alden Laboratories (Aldenlab)
Erich Binder	Worley Compnay
Rob Kaminski	Consultant to Maple Leaf Foods (MLF)
Matt Gaedtke	Greenheck Fan Corp.

MBO Submission to Planning DATE 6/24/2024

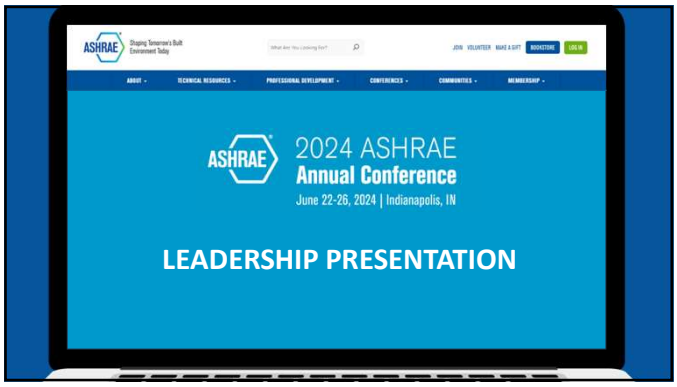
Council: Technology **Chair:** William Bahnfleth
Committee: Environmental Health **Vice-chair:** Marwa Zaatari

MBO #	Description	Metric	Initiative #	Goal #	Completion % / Date	Financial Assist Req'd?	MBO Comments	Strategic Plan Tally											
								Initiative #				Goal 1		Goal 2			Goal 3		
		(how do we determine success?)						1	2	3	4	a	b	a	b	c	a	b	c
1	Revisions to ROB 1.201.004.9	Proposed ROB change submitted	3	3a, 3b	100% 2024 WM	No	Completion will improve speed and flexibility of IAQ standard development			X							X	X	
2	Rule updates related to IEQ-GA	Proposed rules approved, budget support approved	2, 3	1b, 2b, 3b	100% 2024 AM	Yes	Procedures approved by the board in its Nov. 2018 meeting regarding appointments and other aspects of management are not being followed because rules and procedures to not reflect content of the motions that were passed. Proposed ROB changes approved by EHC in IND and sent for approval		X	X			X		X			X	
3	Transition IAQ conference to IEQ focus	Approved process updates, commitment to ongoing support	2,3	1b, 2b, 3a, 3b	75% 2024 AM	Yes	The IAQ conference needs to change to reflect a more integrated approach to IEQ. Recent conferences have emphasised expanded partnerships. Multiple changes are needed to successfully implement the new format. EHC is working with CEC on formalization of procedures to institutionalize the procedures for organizing IEQ Conference. EHC will complete next year.		X	X			X		X		X	X	
4	Complete Epidemic Task Force report	Report submitted to TechC and disseminated as needed	2	1a, 2c	100% 2024 WM	No	Report serves as a reference on main findings and recommendations at sunset of ETF. Report approved and reported to Tech Council in IND.		X			X				X			
5	Convene discussion on future of IAQ standards	Discussions held and recommendations summarized	2, 3	1a, 3b	50% 2024 AM	Possibly (if in-person meeting is held)	ASHRAE Standard 241 introduces a number of significant changes to how IAQ standards are designed (e.g., the use of equivalent clean air as the basis). The board envisioned other ASHRAE IAQ standards (170, 62.1, 62.2, etc.) incorporating 241. EHC Education Subcommitte would work to disseminate Standard 241 technical content. MBO will continue as 24-25 MBO.		X	X		X						X	
6	IEQ standard action plan discussion	Completed report	2	1a, 2b	50% 2024 AM	No	The current strategic plan, under initiative 2, has the outcome "Develop an IEQ standard based on health and productivity objectives that addresses air quality, thermal environment, light, sound, and vibration in an integrated way." A scoping document is needed to discuss what it will take to achieve this, starting from the report of the MTG on health and wellness. MBO will continue as 24-25 MBO		X			X			X				

Council: Technology
Committee: Environmental Health

Chair: Marwa Zaatari
Vice-chair: Max Sherman

								Strategic Plan Tally											
MBO #	**Description**	**Metric**	**Initiative #**	**Goal #**	**Completion % / Date**	**Financial Assist Req'd?**	**MBO Comments**	**Initiative #**				**Goal 1**		**Goal 2**			**Goal 3**		
		(how do we determine success?)						**1**	**2**	**3**	**4**	**a**	**b**	**a**	**b**	**c**	**a**	**b**	**c**
1	Convene discussion on future of IAQ standards	Discussions held and recommendations summarized	2, 3	1a, 3b	50% 2024 AM	Possibly (if in-person meeting is held)	ASHRAE Standard 241 introduces a number of significant changes to how IAQ standards are designed (e.g., the use of equivalent clean air as the basis). The board envisioned other ASHRAE IAQ standards incorporating 241. Discussions to develop a way forward are needed.		X	X		X						X	
2	IEQ standard action plan discussion	Completed report	2	1a, 2b	10% 2024 AM	No	The current strategic plan, under initiative 2, has the outcome "Develop an IEQ standard based on health and productivity objectives that addresses air quality, thermal environment, light, sound, and vibration in an integrated way." A scoping document is needed to discuss what it will take to achieve this, starting from the report of the MTG on health and wellness.		X			X			X				
3	Operational definition of Acceptable Environmental Health		2	1a		No			X			X							
4	Coordinate with 241 (website updates, FAQs)		2, 3	1a,2b,3b		No			X	X		X			X			X	
5	Unified metric of harm and discomfort		2	1a		No			X			X							
6																			



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ASHRAE Policies

ABOUT | TECHNICAL RESOURCES | PROFESSIONAL DEVELOPMENT | CONFERENCES | COMMUNITIES | MEMBERSHIP

Code of Ethics

We will act with honesty, fairness, courtesy, competence, inclusiveness and respect for others, which exemplify our core values of excellence, commitment, integrity, collaboration, volunteerism and diversity, and we shall avoid all real or perceived conflicts of interest.

Harassment and Discrimination

ASHRAE strictly prohibits and does not tolerate discrimination against members or applicants for membership because of such individual's race, color, religion, age, sex, sexual orientation, national origin, physical or mental disability, pregnancy, genetic information, veteran status, uniformed service member status, or any other category protected under applicable law.

Commercialism

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

Value Statement

In ASHRAE meetings, we will act with honesty, fairness, courtesy, competence, inclusiveness and respect for others, which exemplify our core values of excellence, commitment, integrity, collaboration, volunteerism and diversity, and shall avoid all real or perceived conflicts of interest. Our culture is one of inclusiveness, acknowledging the inherent value and dignity of each individual. We celebrate diverse and inclusive communities, understanding that doing so fuels better, more creative and more thoughtful ideas, solutions and strategies for the Society and the communities our Society serves. We respect and welcome all.

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ASHRAE Resources

ABOUT | TECHNICAL RESOURCES | PROFESSIONAL DEVELOPMENT | CONFERENCES | COMMUNITIES | MEMBERSHIP

SOCIETY SNAPSHOT

MARKETING CENTRAL

Logos & Branding Guide
Flyers | Brochures | Presentations | Graphics | Canva Templates

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ASHRAE Resources

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Submit feedback via the Strategic Plan Feedback Form on ASHRAE'S homepage.

Submit

The Planning Committee and ASHRAE Board of Directors are seeking feedback regarding the next Strategic Plan.

We are looking for your feedback on:

- High-priority industry topics
- ASHRAE products and services
- ASHRAE's industry impact

The new ASHRAE Strategic Plan is to be announced at the **2025 Winter Conference.**

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ASHRAE Board of Directors

ABOUT | TECHNICAL RESOURCES | PROFESSIONAL DEVELOPMENT | CONFERENCES | COMMUNITIES | MEMBERSHIP

President

Dennis Knight, P.E. BEMP, Fellow ASHRAE
Mt. Pleasant
South Carolina

President-Elect

Bill McQuade, P.E. Fellow ASHRAE
Jessup,
Maryland

Treasurer

Sarah Maston, P.E., BCxP, LEED AP
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Peachtree Corners,
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Portland, Oregon

Kenneth Fulk, P.E.
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Wade Conlan, P.E. BCxP, CxA
Maitland, Florida

Chandra Sekhar, Ph.D., CPEng.
Fellow ASHRAE
Singapore

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ASHRAE Director and Regional Chairs

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Region I

Charles Bertuch
Manlius, New York

Region II

Genevieve Lussier
Quebec, Canada

Region III

Sherry Abbott-Adkins, P.E., CPD, GPD, LEED AP Westminster, Maryland

Region IV

Bryan Holcomb
Oak Ridge, North Carolina

Region V

James Arnold, P.E.
Dublin, Ohio

Region VI

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La Crosse, Wisconsin

Region VII

Scott Peach, P.E.
Mobile, Alabama

Region VIII

Joseph Sanders
Oklahoma City, Oklahoma

Region IX

Jonathan Smith, P.E.
Lenexa, Kansas

Region X

Buzz Wright, P.E.
Tucson, Arizona

Region XI

Rob Craddock
Saskatchewan, Canada

Region XII

John Constantinide, P.E.
Merritt Island, Florida

Region XIII

Cheng Wee Leong, P.E.,
Singapore

Region XIV

Mahroo Eftekhari, CEng., DPhil
Loughborough, UK

Region XV

Richie Mittal, Fellow ASHRAE
New Delhi, India

Region-at-Large

Bassel Anbari, P.E.
Abu Dhabi, United Arab Emirates

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ASHRAE Directors at Large

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Doug Cochrane, P.Eng.
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Blake Ellis, P.E.
Overland Park, Kansas

Patrick Marks, P.E.
York, PA

Corey Metzger, P.E.
Ames, Iowa

Carrie Brown, Ph.D.
Oakland, California

Wei Sun, P.E.
Ann Arbor, Michigan

David Yashar, Ph.D.
Gaithersburg, Maryland

Luke Leung, P.E, BEMP
Clarendon Hills, Illinois

Heather Schopplein-Anderson, P.E.
Santee, California

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Government Affairs

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GOVERNMENT OUTREACH

Get Involved!

GOVERNMENT AFFAIRS UPDATE

BI-WEEKLY NEWSLETTER

Sign up online or email
GovAffairs@ashrae.org

LETTERS & TESTIMONY

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Research: Supporting ASHRAE's Mission

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Society Year 2023-2024

- **$2.8M Research Promotion Campaign** *(Research, YEA, ALI, Scholarships, General)*
- **$1.4M** Raised for Endowments
- **$232,100** Awarded through 52 Scholarships
- **$2M** Raised for Research
- **$53,000** Raised by College of Fellows and Life Members Club
- **$1M** Given by ASHRAE Regions, Chapters and Sections

More than 4,000 contributions from Members, Organizations and other Associations

These numbers are projections. Actuals will be announced in July.

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Center for Excellence in Building Decarbonization

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New Year, New Name!

Starting July 1, the Task Force for Building Decarbonization will be called:

Center for Excellence in Building Decarbonization (CEBD).

Coming this Fall: Training On the Grid Guide and Hospital Guide

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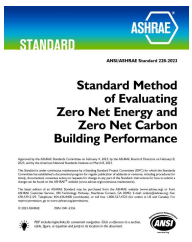
Standards

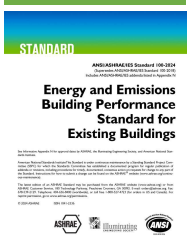
ABOUT | TECHNICAL RESOURCES | PROFESSIONAL DEVELOPMENT | CONFERENCES | COMMUNITIES | MEMBERSHIP

Now Available in Spanish

First of Its Kind



Newly Updated for 2024



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ASHRAE Bookstore

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Get the Latest and Greatest Publications from 2024

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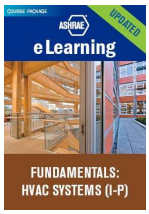
Professional Development

ABOUT | TECHNICAL RESOURCES | PROFESSIONAL DEVELOPMENT | CONFERENCES | COMMUNITIES | MEMBERSHIP

eLearning

Recently Updated



ASHRAE Learning Institute

New Trainings in Indianapolis
Standard 241
Control of Infectious Aerosols

Understanding Standard 241
June 25 | 9 AM

Applying Standard 241
June 25 | 1 PM

Certification

New Certification

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2024-25 Topical Conferences

ABOUT | TECHNICAL RESOURCES | PROFESSIONAL DEVELOPMENT | CONFERENCES | COMMUNITIES | MEMBERSHIP

Chicago, September 26-27, 2024
Women in ASHRAE Leadership Symposium

Beirut, Oct 3-4, 2024
The Sixth International Conference on Efficient Building Design

New York City, October 21-23, 2024
2024 ASHRAE Decarbonization Conference: Decarbonizing Existing Tall Buildings

Qatar, April 23-24, 2025
Third International Conference on Energy and Indoor Environment for Hot Climates

Montreal, September 24-26, 2025
IEQ 2025 Conference

NOW Check the App for the CIDCO sessions happening this week!

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2025 ASHRAE Winter Conference

ABOUT | TECHNICAL RESOURCES | PROFESSIONAL DEVELOPMENT | CONFERENCES | COMMUNITIES | MEMBERSHIP

ASHRAE

2025 ASHRAE
WINTER CONFERENCE
ORLANDO, FEB 8-12 | AHR EXPO, FEB 10-12

Registration opens in fall 2024. See you in Orlando!

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New ASHRAE Region XV

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Director and Regional Chair: **Bassel Anbari**

Director and Regional Chair: **Richie Mittal**

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Get Involved with Committees & Chapters

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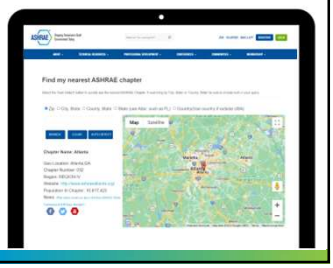
Find Committees and Nominate Yourself or Others

FEB 2024 — **February:** Nominations for appointed committees are due.

JUN 2024 — **June:** Speak with your committee ExO/CO if your current appointment/elected position ends to be nominated for another.

SEP 2024 — **September:** Nominations for elected positions are due. (Publications & Education Council, Tech Council, RAC, TAC, Standards, Handbook, Nominating)

Find Chapter Information Using the Chapters Map



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Membership

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NEW Benefit!

ASHRAE Guidelines added to annual membership benefit selection for new & renewing full dues paying members.

eLearning Course	ASHRAE Standard or Guideline	ASHRAE Handbook	Handbook Online	ASHRAE Certification Exam Study Guide
95+ to choose from	100+ to choose from	PDF version of the most recent	4 most recent	3 to choose from

Honors & Awards

The following award nominations have a DEC 1 deadline:

Fellow | Honorary Member | ASHRAE Hall of Fame | F. Paul Anderson Award
ASHRAE Pioneers of the Industry | ASHRAE Award for Distinguished Public Service

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Join Us at the President's Luncheon

Empowering Our Workforce: Building a Sustainable Future

Monday, June 24
12:15 – 2:00 PM
Tickets available at Registration

2024-25 ASHRAE President
Dennis Knight, P.E., BEMP, Fellow ASHRAE

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Media Inquiries

Asked to make a statement on behalf of ASHRAE?

Please send all media inquiries to publicrelations@ashrae.org before responding to members of the press.

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Thank you!
Questions or Comments?

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Spring 2024

Environmental Health Committee (EHC) Report to ASHRAE Technology Council

Recent Trends in Environmental Health

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

1. *Implementation Science* This new approach/discipline addresses a major gap in public health efforts: how do leaders and researchers best promote and ensure faithful and sustained compliance with recommended measures to improve the public's health. In the context of ASHRAE, this will include the study of how to, and why, standards and position documents are adhered to by engineers as well as building owners and management. This area is a major interest of the NIEHS and EPA that seek to develop evidence-based strategies to implement and assess the impact of an organization such as ASHRAE.

2. *Pandemic Preparedness* The concern is about another pandemic such as Covid 19 potentially due to an organism engineered to have more dangerous properties such as resilience with respect to humidity, temperature, and resistance to biocidal agents (e.g., UV), This is a nightmare scenario. Engineers are being asked by building owners to put in place constant or variable protective measures. These measures seem increasingly prudent. However, we need to know how to choose among a variety of strategies (increased ventilation with outdoor air; better filtration; UVC and other GUV, TREG). These measures could be constant modifications, or they might be implemented when needed by "flipping a switch". We need to determine what are the relative efficacy, effectiveness, costs, and sociological concerns.

3. *Is CO2 a Poison?* The possibility that indoor exposures to elevated concentrations of CO2, above 1,000 ppm, may result in impaired executive function is a serious public health concern. This possibility is supported by a substantial body of human experimental research and literature. More research is needed to clarify the existence and magnitude of this potentially massive public health challenge.

4. *Environmental Justice* The concern is that communities of color and lower SES have greater exposure to air pollutants, both outdoors and consequently indoors. This is a growing area of concern in federally funded air pollution research. It is also gaining stature as a leading concern for air quality researchers. EPA, NIEHS, and HUD are all concerned with the implications of this aspect of environmental public health.

5. *Indoor to Outdoor Transport of Air Pollutants* The relevance of this inverse of pathways of exposure to particulate matter (PM) and other air pollutants is

increasingly recognized as an important consideration in overall exposure of the public to air contaminants. Sources such as commercial cooking and indoor to outdoor transport of the products of indoor chemistry make this actionable through a variety of approaches as outlined in a recent American Thoracic Society publication.

6. *Retrofitting of Existing Building Stock* How to, and at what cost will we retrofit buildings for the purpose of reduced energy consumption as well as improved indoor air quality. These are important issues when it comes to retrofitting or designing HVAC systems. If pandemic preparedness requires changes to the HVAC systems as part of the building readiness plan, how do disadvantaged communities without mechanical ventilation in many residential buildings address health issues of the occupants in these buildings? What are the ethical considerations?

7. *Building Operations Data* Modern construction with smart controls for HVAC systems collect and store vast amounts of operational data regarding temperature, humidity, lighting, noise, occupant satisfaction, etc. What is being done with this information to inform architects and engineers about future improved building design, maintenance and operations? Who should be responsible to collate and curate this data so that all of us can learn from real world experience?

ASHRAE IAQ Conference – Long Range Plan
June 24, 2024

Past History

The first ASHRAE IAQ conference in 1986 was held “to review the latest research in indoor air pollution and provide missing current data for Standard 62”. It was understood that “the indoor environment should minimize any impact on health and should be free of any impact on comfort, and control should minimize the use of energy.” Implicit in this statement is the belief that the performance measures needed to realize this goal could be defined in practical terms. It was also decided that ASHRAE would organize an IAQ conference starting in 1987. This speciality conference was subsequently held in different intervals through 2016 with most recent conferences held in 2016 and 2022 for a total of nineteenth conferences.

Thirty years later in 2016, 174 delegates from 21 countries met in Alexandria, Va., for the 11th ASHRAE IAQ conference. The conference was co-organized with the Air Infiltration and Ventilation Centre (AIVC) as its 37th annual meeting. The Indoor Environmental Quality Global Alliance (IEQ-GA) was one of partner organizations. Participants included members of the scientific community, representatives from government agencies, designers, and IAQ practitioners. Meetings of the ASHRAE Environmental Health Committee, IEQ-GA Board of Directors, the AIVC Board of Directors, and an ASHRAE residential stakeholder workshop were coordinated with the conference.

Due to the COVID pandemic, the IAQ conference to be held in 2020 was postponed. The next ASHRAE IAQ Conference was held in May 2022 in Athens, Greece. The conference was again co-sponsored by the Air Infiltration and Ventilation Centre (AIVC) as its annual meeting. Also, the 9th TightVent and 7th venticool conference were held as part of this conference. Indoor Air Quality (IAQ) has been the core of ASHRAE’S IAQ series of conferences for the past 30 years. This conference held in 2022 expanded from Indoor *Air* Quality to Indoor *Environmental* Quality (IEQ). IEQ includes air quality, thermal comfort, acoustics, and illumination and their interactions. The particular focus of this conference was on performance approaches including the metrics, systems, sensors, and norms necessary to implement them.

<u>Future Conferences – 2025 and 2028</u>

Planning began for the twentieth 2025 ASHRAE IEQ Conference shortly after the close of the 2022 conference. It has been decided that the 2025 conference will be held in Montreal, Quebec, Canada in September 2025. Once again, the conference will be co-sponsored by ASHRAE and AIVC. The theme of the conference is: Rising to new challenges: Connecting IEQ to a sustainable future.

This conference provides the opportunity to learn, network and engage with IEQ professionals dedicated to advancing the fields of indoor environmental quality. Emphasis is placed on the growing understanding of occupant response to indoor

environment elements (thermal, air quality, lighting, and acoustics) while enhancing resilience in a changing climate.

It is expected that this conference will be well-attended by IEQ experts, scientists/researchers, practitioners, and governmental representatives from around the world. The topics for papers and seminars to be presented include:

- Performance Metrics: For all aspects of IEQ
- Occupant Behavior: How behavior impacts IEQ and how IEQ impacts behavior - psychological dimensions of IEQ
- Smart Sensors, Data and Controls: Sensor properties, data management, cybersecurity, applications, commissioning, equivalence
- Resilience and IEQ: Responding to climate change and disasters.
- Ventilation: Mechanical, passive, natural and hybrid systems
- Air Tightness: Trends, methods, and impacts
- Thermal Comfort: Dynamic approaches, health impacts and trends
- Policy and Standards: Trends, impacts, implications
- HVAC and IEQ in a post-COVID world
- Ventilation and building decarbonization.

It is anticipated that there will be an ASHRAE IEQ Conference in 2028, and then every three years henceforth.

ASHRAE Topical Conferences

It is noted that the 2025 ASHRAE IEQ Conference is shown on the ASHRAE website as one of ASHRAE's Topical conferences. Other topical conferences as listed on this webpage include:

- The Sixth International Conference on Efficient Building Design
- Third International Conference on Energy and Indoor Environment for Hot Climates

It is noted that these conferences are held on a schedule of either annually or every two or three years. In that regard, the IEQ 2025 Conference will be the twentieth conference to be held on this topic (IAQ/IEQ), currently on a three-year schedule, excluding the postponements associated with the pandemic.

Requests for Future Conferences starting in 2028

1) It is currently understood by all parties that the triannual ASHRAE IEQ Conference must be approved by the appropriate ASHRAE Committees prior to engaging with a Steering Committee and ASHRAE staff to plan the conference. Our request is that the ASHRAE Environmental Health Committee (EHC) be the designated committee to approve this conference on a three-year schedule, like the Topical Conferences shown above.

2) The budgeting, location, marketing, sponsorship, paper reviews, and timing of the ASHRAE IEQ Conference would be discussed by the conference steering committee with ASHRAE Staff to ensure a successful and well-planned conference. The EHC members would be requested to assist in these tasks as well. All plans and budgeting would be conducted in accordance with the ASHRAE Technology Council's Reference Manual.