ASHRAE Shaping Tomorrow's Built Environment Today

MINUTES

Environmental Health Committee (EHC)
June 29, 2016
Marriott St. Louis Grand
St. Louis, MO

MEMBERS PRESENT:
Zuraimi Sultan, *Chair*
Wane Baker, *Vice Chair*
Bill Bahnfleth
Costas Balaras
Paul Francisco, *Consultant*
Elliott Horner
Kevin Kennedy
Ben Leppard, *BOD Ex-O*
Claressa Lucas
Lan-Chi Nguyen-Weekes
Bill McCoy
Andy Persily
Larry Schoen
Jeff Siegel

MEMBERS NOT PRESENT:
George Araj
Jill Baumgartner
Dennis Stanke
Jim Vallort, *Coord. Officer*

ASHRAE STAFF:
Steve Hammerling, *AMORTS*

GUESTS:
Nick Agopian
Hans Besselink, *Incoming Member*
Hoy Bohanon
Clive Broadbent, *Incoming Member*
Nicholas Clements
Wade Conlan, *Incoming Member*
Aaron Duda
Steve Emmerich
Lew Harriman
Mark Jackson
Joesphine Lau
Tom Lawrence, *Incoming BOD Ex-O*
Luke Leung
Frederick Marks
Patricia Mason-Fritz
Eric Saunders
Chandra Sekhar, *Incoming Member*
Scott Sherwood
Erica Stewart
Janet Stout
Wayne Thomann
Pawel Wargocki, *RAC Liaison*
Don Weekes
Michael Woodford
Jie Zhao

Table of Contents

MOTIONS

No.	Motion	STATUS
1	the minutes from the EHC Winter Meeting in Orlando be approved.	PASSED
2	the minutes from the EHC spring meeting be approved.	PASSED
3	that EHC recommend to that Technology Council reaffirm the *Environmental Tobacco Smoke (ETS)* PD.	PASSED
4	EHC approve an Emerging Issue Brief (EIB) on Environmental Impact of Air Cleaning Building Materials and Coatings	PASSED
5	EHC sponsor the following four seminars for presentation at the 2017 Winter Meeting in Las Vegas: • Nano-techology – potential exposures (seminar) • Dampness in Homes, Mold and Allergen Assessments (seminar) • Legionellosis (188 implementation, PD update, toolkits, outbreak analysis) (workshop) • Energy Retrofits – IAQ in Existing Homes (seminar)	PASSED
6	EHC co-sponsor TC 2.3 WS 1579, *Testing and Evaluation of Ozone Filters for Improving IAQ*.	PASSED

ACTION ITEMS FROM 2016 ANNUAL MEETING IN ST. LOUIS

No.	Responsibility	Action Item	Page
SL-1	**Sekhar, Schoen, TC 9.6**	Review and determine if a revision or reaffirmation o *Airborne Infectious Diseases* PD is appropriate	3
SL-2	**Staff**	Post *Environmental Impact of Air Cleaning Building Materials and Coatings* EIB to EHC page of ASHRAE website	4
SL-3	**Schoen, Kennedy**	Develop draft EIB on e-cigarettes	4
SL-4	**Leung**	Develop draft EIB on criteria for PM2.5 concentrations	4
SL-5	**Siegel**	Find subject matter expert to finish draft WS-1657 - *Effective Ventilation Systems for Airborne Infection Isolation Rooms to Reduce Potential Cross Infection*	5
SL-6	**Staff**	Send new members information on the EHC research roadmap and latest RTAR form	6
SL-7	**Persily**	Review Standards Actions on a weekly basis and distribute as appropriate	7
SL-8	**Wargocki, Persily, Weekes**	Develop draft EIB on Physiological Impact of CO_2 in the Indoor Space	8

ACTION ITEMS FROM 2016 SPRING MEETING

No.	Responsibility	Action Item	Status
SP-1	**Siegel**	Determine if Zhang OK with an additional PMS member and ask EHC for letter ballot approval of Francisco to PMS	Complete
SP-2	**Siegel**	Submit RTAR on *Airborne transmission of respiratory infectious disease in students' dormitories under different ventilation conditions with and without UVGI devices* to RAC by May 15th	Complete
SP-3	**Lucas**	Submit draft RTAR on *Experimental Evaluation of the Effective Dosage of Legionella Delivered by Aerosolizing Devices in Building Water Systems* to RL by end of May/early June	Delete
SP-4	**Weekes**	Weekes agreed to draft and submit RTAR on *Monitoring for legionella/bacteria and chemical pollution with in plants/green walls* to RL by end of May	Ongoing
SP-5	**Siegel**	Communicate with NIST expert and draft an RTAR on new refrigerant impact on flame retardant use as appropriate	Complete
SP-6	**Weekes**	Weekes to send final chapter F10 to Handbook Committee Liaison	Complete
SP-7	**Weekes**	Lead effort to review changes to Green Guide chapter on IEQ with and coordinate with TC 2.8	Complete
SP-8	**Sultan**	Draft letter to TC 2.8 to help ensure EHC be contacted and formally responsible for review of IEQ chapter in Green Guide going forward	Complete
SP-9	**EHC**	Recommend action to Balaras for Airborne Infectious Diseases PD to be retired, revised, or reaffirmed	Ongoing
SP-10	**Persily/Weekes**	Review *Environmental impact of air cleaning building materials and coatings* EIB to determine if their comments were adequately addressed in revision.	Complete
SP-11	**Horner/Kennedy**	Prepare seminar proposals related to studies on various allergies programs and practices for EHC to consider in STL	Complete

ACTION ITEMS FROM PRIOR MEETINGS

No.	Responsibility	Action Item	Status
OR-9	**Francisco**	Determine if EIB on “Does Weatherization Make Buildings Less or More Healthy” was appropriate	Ongoing
CH-11	**Schoen / Kennedy**	Develop draft of e-cig brief	See SL-3

LIST OF ATTACHMENTS

No.	Attachment
A	2015-2016 MBOs
B	Environmental Tobacco Smoke PD
C	MTG.Building Dampness final report
D	Environmental Impact of Air Cleaning Building Materials and Coatings Emerging Issue Brief
E	Potable Hot Water Temperature – Safe and Sensible Temperature Levels that Take into Account Issues with Scalding, Legionella, and Conservation RTAR

LIST OF ACRONYMS

AHRI	Air-conditioning, Heating, and Refrigerating Institute
AID	Airborne Infectious Diseases
AIVC	Air Infiltration and Ventilation Center
AMORTS	Assistant Manager of Research and Technical Services
BOD	Board of Directors
CBE	Center for the Built Environment
CO	Coordinating Officer
CO_2	Carbon Dioxide
CNV	Chair Not Voting
DOAS	Dedicated Outdoor Air System
DOE	Department of Energy
DRSC	Document Review Subcommittee
EHC	Environmental Health Committee
EHS	Environmental Health & Safety
EIB	Emerging Issue Brief
ETS	Environmental Tobacco Smoke
ExO	Ex-Officio
GWP	Global Warming Potential
IAQ	Indoor Air Quality
IAQA	Indoor Air Quality Association
IEQ	Indoor Environmental Quality

IEQ-GA	Indoor Environmental Quality Global Alliance
IICRC	Institute of Inspection, Cleaning and Restoration Certification
MBO	Management by Objectives
MOP	Manual of Procedures
MTG	Multi-disciplinary Task Group
PD	Position Document
PEAC	President Elect Advisory Committee
PM	Particulate Matter
PMS	Project Monitoring Subcommittee
RAC	Research Administration Committee
ROB	Rules of the Board
RL	Research Liaison
RP	Research Project
RTAR	Research Topic Acceptance Request
SSPC	Standing Standard Project Committee
TAC	Technical Activities Committee
TC	Technical Committee
TPS	Title Purpose and Scope
UVGI	Ultra-Violet Germicidal Irradiation
WS	Work Statement

1. CALL TO ORDER & INTRODUCTIONS

Chair Zuraimi Sultan called the meeting to order at just after 2:15 PM. Members and guests introduced themselves.

2. REVIEW OF AGENDA

No changes were made to the agenda sent prior to meeting. Sultan noted subcommittee reports would focus on motions and discussion items from subcommittee meetings, not information items.

3. MINUTES

Minutes from past EHC meetings were sent via email.

It was moved (ZS) and seconded (CL) that,

(1) the minutes from the EHC Winter Meeting in Orlando be approved.

MOTION 1 PASSED: 11-0-0, CNV

It was moved (ZS) and seconded (CL) that,

(2) the minutes from the EHC spring meeting be approved.

MOTION 2 PASSED: 11-0-0, CNV

4. CHAIR'S REPORT (Sultan)

A. The following motions from past EHC meetings required higher body approval:
- Motion to appoint Michael Patton as chair of Legionellosis Position Document (PD) chair passed Tech Council via letter ballot. Patton was sent formal appointment letter.
- Motion to revise the Indoor Air Quality (IAQ) PD Title, Purpose and Scope (TPS) was passed by Tech Council and ExCom.
- Motion to appoint chair and members to the Environmental Tobacco Smoke (ETS) PD committee was passed by Tech Council. Members were sent formal appointment letters.

B. New Information Items
- EHC's strategic discussion topic for Annual Meeting will be Physiological Impact of CO_2 in the Indoor Space.
- EHC continues to monitor work of Indoor Air Quality PD and Energy Efficiency in Building PD.
- Motion from PD committee to approve Combustion of Solid Fuels and IAQ in Primarily Developing Countries did not pass Tech Council in spring. PD draft was since reworked and resubmitted to reconsider in STL.

C. 2015-2016 Management by Objectives (MBO's) – Status Report (**Attachment A**).
EHC will report final status of MBOs in report to Operations Subcommittee.

D. Indoor Environmental Quality – Global Alliance (EQ-GA) (Olesen)
Bahfleth reported on behalf of Olesen. The formal ad hoc committee is ending soon as IEQ-GA becomes its own entirety. ASHRAE will continue to support IEQ-GA as Secretariat and with some operational funding. The IEQ-GA is finalizing operational agreement together and will met in STL and again at IAQ 2016 in Alexandria.

5. VICE-CHAIR'S REPORT (Baker)

A. ROB/MOP/Reference Manual
No changes suggested at this time.

B. Budget
No changes were requested to EHC budget. Most line items are currently under budget.

C. Environmental Health Award
Baker noted the ASHRAE Environmental Health Award was awarded to Francis 'Bud' Offermann at the ASHRAE Annual Meeting in St. Louis. Nominations for next year's award are due October 1st.

6. BOARD OF DIRECTORS (BOD) EX-OFFICO (ExO) & COORDINATING OFFICER (CO) REPORT

A. BOD Ex-Officio - Leppard
Leppard thanked EHC for efforts on behalf of BOD and presented PEAC report. Highlights included the following:

- Change to role of PEAC going forward to be more of a planning committee.
- ASHRAE sought outside consultant on Strategic Plan
- BOD meeting in Bangkok in fall.
- $1.2M approved from ASHRAE research reserve for 2L refrigerant research. Part of $5.2M in funding from DOE, AHRI
- ASHRAE certifications now ANSI accredited
- 2016 publications include Standard 62.1, 62.2, 90.1, 55 User's Manual, 160, 52.2, DOAS, Cleanrooms
- IAQ 2016, *Defining Indoor Air Quality: Policy, Standards and Best Practices* in September 2016 in Washington DC.

7. IAQ 2016 CONFERENCE (Bahnfleth)

IAQ 2016, *Defining Indoor Air Quality: Policy, Standards and Best Practices*, is co-organized by AIVC and will take place September 12-14th, 2016 in Alexandria VA. EHC and IEQ-GA are meeting at the conference. Registration is now open. A preliminary program should be set in next couple weeks. A great conference is anticipated. More information is available at www.ashrae.org/iaq2016.

8. SUBCOMMITTEE REPORTS

A. Handbook Subcommittee (Weekes)

1.0 2017 Fundamentals chapter F10
Weekes reported the revised chapter F10, *Indoor Environmental Health*, was submitted to Handbook committee. Baker and EHC thanked Weekes for the significant amount of work done to complete the revision.

2.0 Green Guide revisions
EHC has agreed to look at revisions to the IEQ chapter in the next edition of the ASHRAE Green Guide. The chapter will be shortened considerably to be consistent with the length and format of other chapters and will reference guidance from the IAQ Design Guide publication as appropriate. EHC had considered sending letter to Tech Council to assure future involvement in chapter revisions but will work with TC 2.8 as a liaison instead.

B. Policy Subcommittee (Balaras)

1. Position Documents
   A. Legionellosis

Baker reported Michael Patton was approved and appointed as chair of the *Legionellosis* PD committee. Patton will convene a fall meeting and aims to complete draft by end of year.

B. *Combustion of Solid Fuels and IAQ in Primarily Developing Countries*
The PD was not approved by Tech Council in the spring so the PD committee made changes in response to comments received. The PD committee has submitted the revised draft to DRSC for reconsideration in STL.

C. Indoor Air Quality
Progress continues on the revision to the *Indoor Air Quality* PD. Changes to the TPS requested in Orlando were since approved. The committee is meeting in St. Louis.

D. *Environmental Tobacco Smoke*

Policy Subcommittee moves that,

(3) that EHC recommend to that Technology Council reaffirm the *Environmental Tobacco Smoke (ETS)* PD.

BACKGROUND: The current PD (**Attachment B**) expires June 25, 2016. A committee to revise the PD has already been approved and appointed. The revision will put the PD into the latest ASHRAE PD template, update references, and include some editorial changes. It is anticipated that a revised PD would be available before the Winter Meeting.

MOTION 3 PASSED: 11-0-0 CNV

E. Airborne Infectious Diseases
The *Airborne Infectious Diseases* (AID) PD expires January 17, 2017. Sekhar, with help from Schoen and members of TC 9.6, Healthcare Facilities, agreed to review and determine if a revision or reaffirmation is appropriate (**AI #SL-1**).

F. Other
Lew Harriman presented final report of MTG on Building Dampness (**Attachment C**). This MTG was formed in response to recommendation in Mold PD. Committee offers description of building dampness, not a definition. The report will be sent to TAC for guidance on next steps(s) but Lew is seeking feedback from TC 1.12 and EHC. Comments include:

- Report should explicitly make distinction between description offered in report vs. definition of damp building.
- Should ASHRAE seek outside review? (IAQA, IICRC, public health authorities, envelope experts, American Academy of Allergy, Asthma and Immunology)
- Report may warrant changes to ASHRAE position document.
- Report authors should include recommendation on next steps.
- Consider developing into ASHRAE guideline or other publication?

2. Emerging issue briefs
   A. Review of current emerging issue briefs

Nanoparticle environmental health and safety (nano-EHS) was posted to ASHRAE website. Draft of Environmental Impact of Air Cleaning Building Materials and Coatings reviewed and ready for approval.

Policy Subcommittee moves that,

(4) EHC approve an Emerging Issue Brief (EIB) on Environmental Impact of Air Cleaning Building Materials and Coatings

BACKGROUND: Weekes presented final version of brief (**Attachment D**) with agenda. EHC has reviewed and commented on a number of times.

MOTION 4 PASSED: 11-0-0 CNV

Staff will post to EHC page of ASHRAE website (**AI #SL-2**).

B. Other/New Reports
Balaras asked for other or new ideas for possible EIBs. Other ideas for future development: e-cigarettes (Schoen/Kennedy) (**AI # SL-3**), low GWP 2L refrigerants and safety issues (Siegel), criteria for PM2.5 concentrations (Leung) (**AI # SL-4**), and weatherization impact on health (Francisco).

C. <u>Education/Program Subcommittee (Schoen)</u>
1. EHC Sponsored Programs
A. St. Louis program
EHC sponsored or co-sponsored two programs at the 2016 Annual Meeting in St. Louis:
- Seminar 29 (co-sponsor) - Why Be Concerned with Indoor Carbon Dioxide Concentration?
- Seminar 62 - Is It My Home or Is It Me? Latest Knowledge about IAQ in Homes

B. Las Vegas programs
EHC discussed a number of possible programs to submit for the Winter Meeting in Las Vegas.

Program Subcommittee moves that,

(5) EHC sponsor the following four seminars for presentation at the 2017 Winter Meeting in Las Vegas:
- Nano-techology – potential exposures (seminar)
- Dampness in Homes, Mold and Allergen Assessments (seminar)
- Legionellosis (188 implementation, PD update, toolkits, outbreak analysis) (workshop)
- Energy Retrofits – IAQ in Existing Homes (seminar)

MOTION 5 PASSED: 11-0-0, CNV

Weekes to chair Nanotechnology program with Patricia Mason, TC 2.3, TC2.4, and Persily's contact participating as possible speakers. Kennedy would chair allergy program with Horner, David Miller as possible speakers. Lucas would chair 60-90 minute workshop with Patton, Watson, Koontz and Mills as possible speakers. Focus would be to offer guidance for members in implementing risk management plan in Standard 188. Siegel agreed to chair energy retrofit seminar.

Conlan suggested working with track chairs, doing some marketing and promotion and fitting the conference themes to help get programs approved. Conlan agreed to review program requests before submission if requested.

EHC discussed more ideas for possible programs in Long Beach or other future ASHRAE meetings. These include a program on the healthcare HVAC (history, natural ventilation, anteroom or no anteroom, environmental marijuana smoke).

2. ASHRAE Journal IEQ Applications Column
EHC discussed commitments to author column articles. Some more commitments and ideas were collected. The updated draft list is shown below:

Issue	Draft due	Author	Topic
March 2016	Published	Schoen	New Residential IAQ Guide
April 2016	Published	Baker	e-cigarette seminar in Orlando
May 2016	Published	McCoy	Lessons from Flint water situation
June 2016	Published	Francisco	IAQ and residential weatherization
July 2016	In review	Zuraimi	Air cleaning surfaces
August 2016	July 1	Chemaly	UV decontamination in hospitals
September 2016	August 1	Fritz	Biomass emissions
October 2016		**???**	**???**
November 2016	Oct. 1	Lucas	summary of MMWR article
December 2016	Nov. 1	Nguyen-Weekes	NYC (others?) cooling tower rule
January 2017	Dec. 1	Kennedy/Horner	dampness and health
Other potential columns that have been mentioned			
Bahnfleth on UVGI – cooling coil irradiation			
Persily for October			
Besselnick – hybrid ventilation – practitioner experiences			

D. Research Subcommittee (Siegel)

1. Active Research Projects (RP)
RP - 1663 – *Residential IAQ Guide*
Project is well underway with four of the eight chapters at 70% draft form and in review. The PMS is meeting every four weeks and is meeting in STL. Current goal for completion is early 2017. The PMS chair agreed not to replace lost member.

2. Work Statements (WS)
Draft WS-1657 - *Effective Ventilation Systems for Airborne Infection Isolation Rooms to Reduce Potential Cross Infection*
McCoy and Araj worked on a draft but still needs more pieced filled in. A subject matter expert is really needed to take to final step. Siegel agreed to seek expert to work on draft (**AI # SL-5).**

3. Research Topic Acceptance Requests (RTARs)

A. *Draft RTAR-1803 - Airborne transmission of respiratory infectious disease in students' dormitories under different ventilation conditions with and without UVGI devices*
Siegel reported RAC returned RTAR 1803 with comments. It was not rejected so it can be reworked and resubmitted by EHC if desired. Concerns are related to 1) reliance on major metric of self-reported symptoms, 2) UVGI insufficiently characterized.

B. Draft RTAR on *Experimental Evaluation of the Effective Dosage of Legionella Delivered by Aerosolizing Devices in Building Water Systems (Lucas)*
Lucas noted this RTAR would be with an RTAR on *Potable Hot Water Temperature – Safe and Sensible Temperature Levels that Take into Account Issues with Scalding, Legionella, and Conservation (***Attachment E***)*. Lucas noted the draft should be formalized and completed but this can be put on the radar Siegel would follow up with Tim Kuehn.

C. Draft RTAR related to monitoring for legionella/bacteria and chemical pollution with in plants/green walls (Weekes)
Weekes noted she would try to complete RTAR and distribute for possible Fall letter ballot.

D. New/Other RTAR ideas
TC 2.3 requested co-sponsorship of WS 1579, *Testing and Evaluation of Ozone Filters for Improving IAQ*. This project is a follow up to RP-1491. Kathleen Owen is close to completing draft and will send to EHC to consider co-sponsorship.

It was moved (JS) and seconded (WB) that,

(6) EHC co-sponsor TC 2.3 WS 1579, *Testing and Evaluation of Ozone Filters for Improving IAQ*.

MOTION 6 PASSED: 11-0-0, CNV

Siegel encouraged all to develop RTARs for EHC consideration. EHC membership is not a requirement to draft an RTAR. Other possible RTARs mentioned included one from Luke Leung related to outdoor design criteria for PM2.5 and PM as a function of building height.

4. Research Road Map
Siegel referred members to EHC research roadmap as useful for ideas. Staff agreed to send new members information on the EHC research roadmap and latest RTAR form (**AI # SL-6**). Besselnik noted ASHRAE can work with REHVA and seek input for them on possible research as well.

5. Other
EHC's research liaison (RL) to RAC noted funds are available for ASHRAE research but the expectations for quality in RTARs and WS is very high so it is generally not easy to get documents approved by RAC. Wargocki and Siegel recommended using RL to help review, liaise, and advocate for EHC research. Deadlines for RAC research consideration are May, August and December 15th so EHC can ballot projects for RAC consideration in the fall. Don Weekes noted RAC is looking for answer to question "ASHRAE should fund this research?", so proposals should make this explicitly clear. Their current emphasis is on applied research of immediate interest to members.

9. STANDARDS ACTIVITIES

A. Standard 188

Lucas reported SSPC 188 is meeting in St. Louis. No major news on the standard since the last EHC meeting. SSPC 188 is revising Guideline 12 as well.

B. Standard 55

Schoen noted the Standard 55 User's Manual was approved and should be available soon. There are also negotiations underway to make the thermal comfort tool from the Center for the Built Environment (CBE) available as part of Standard. In general, there is a move away from the use of the psychrometric chart for compliance and towards available analytical tools. There is still no minimum humidity limit being explored by committee.

C. Standard 62.1

Bohanon noted the 2016 version of 62.1 was published earlier this year. A 2016 User's Manual is in development. Addenda for 2019 version are already in development. A proposal for an ASHRAE Guideline for a better than minimum IAQ has been proposed. Bohanon agreed to keep EHC involved in the Guideline proposal.

D. Standard 62.2

Francisco noted 62.2-2016 was published earlier in year. A proposed scope change would apply for 62.2 to apply to dwelling units in any building. 2019 version will include a change to allow decreased ventilation if increased filtration is installed. This was brought to attention of EHC previously without comment. EHC may wish to evaluate standard changes affecting environmental health more closely.

E. Standard 189.1

A change out for public review bans unvented combustion devices with two exceptions. More addenda are in development related to strengthening acoustic requirements, requiring IEQ surveys, and changes to daylighting, and glare and view requirements.

F. Guideline 10

Mark Jackson reported no major changes to updated guideline.

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

Horner would serve on standard committee which will be developed by ASHRAE and IAQA under ASHRAE standard development procedures. The committee has been set up but effort is in very early stages.

H. Others

- EHC will include discussion of Standard 170, Ventilation for Healthcare Facilities, on agenda going forward.

- Sultan recommended EHC take a more active role in participating in standards issues impacting environmental health. EHC may wish to review standard change proposals like is done on research projects to see if EHC should be involved or participate in public review proposals. Emmerich noted comments to Standards do come from individual as opposed to committee and that notifications for proposed changes are available by list server. Persily agreed to review standards actions on a weekly basis and distribute as appropriate (**AI # SL-7)** to see how this works.

10. STRATEGIC DISCUSSION

A. Physiological Impact of CO_2 in the Indoor Space – P. Wargocki
EHC has restructured their meeting format to again include significant time on the agenda for 'strategic scientific discussions'. The topic at this Annual Meeting was *Physiological Impact of CO_2 in the Indoor Space.* Wargocki prepared a presentation (members may contact Wargocki for PPT) and led a discussion. The presentation summarized and compared some major research on the topic. Wargocki did not recommend ASHRAE pursue new research or a position document. An emerging issue brief may be more appropriate (**AI # SL-8**). Weekes and Persily agreed to work with Wargocki.

11. NEXT MEETINGS

A. IAQ 2016, Washington DC, 1:00-5:00 PM Sept. 11, 2016

B. Winter Meeting, Las Vegas, NV, January 30, 2017

C. Sultan recognized outgoing members (Costas Balaras, Paul Francisco, Larry Schoen, Dennis Stanke) with a certificate of appreciation.

12. NEW BUSINESS

A. Staff from Delos delivered a presentation on the WELL Building Program. Nearly 1 million square feet of buildings are certified globally. More details available at www.wellcertified.com.

B. Baker recognize outgoing chair (Zuraimi Sultan) and incoming members (Hans Besselink, Clive Broadbent, Wade Conlan, Chandra Sekhar, Shin-ichi Tanabe) to the committee.

C. Proposed 2016-17 MBOs and Subcommittee Assignments
Baker noted he'd present MBOs to Tech Council and contact members on subcommittee assignments in the near future.

13. ADJOURNMENT

The Environmental Health Committee meeting was adjourned at approximately 6:15 PM.

Environmental Health Committee 2015-2016
Zuraimi Sultan, Chair
6/27/2016

Item #	MBO	Date Due	Assigned To	Applicable Strategy #	MBO Comments	MBO Status
Research						
1	Support EH-related ASHRAE Research	30-Jun-16	Research Subc.	1.1., 1.2, 1.3, 1.5, 1.7, 1.8	EHC will identify top priority research activities that will support ASHRAE's strategic plan but are not currently being conducted through TCs. EHC will identify 2 RTARs and their champions through this process, and will coordinate with applicable TCs to co-sponsor these projects. UVGI RTAR to be developed into WS by the end of 2015-2016.Additionally, EHC will continue to monitor existing project (RP-1663).	EHC approved UVGI RTAR-1803 to send to RAC. EHC is co-sponsoring a 62.2 RTAR and TC 2.3 WS 1579 EHC continues to monitor RP-1663 Four more RTARs in development
2	Support ASHRAE Research by providing an EH perspective	ongoing	Francisco	1.1., 1.2, 1.3, 1.5, 1.7, 1.8	Review all RTARS to provide inputs to RAC on environmental health related projects. This activity will continue, to ensure that important EH issues of which RTAR authors may not be aware are considered.	EHC reviewer RTARs ahead of RAC's Fall, Winter Meetings, and Annual Meetings
Education/Program						
3	Enhance EHC Education and Outreach Program	ongoing	Persily, Schoen	1.2, 2.8, 3.1, 3.4	Articles covering environmental health issues have been placed in most issues of the ASHRAE Journal for a few years. Contributions are slowing -- this activity needs to be revitalized and continued. Additionally, in order to ensure that EH issues and perspectives are available to the ASHRAE membership, EHC will submit session abstracts for every conference and work with CEC to ensure that EHC issues have a presence in the conference programs. Finally, EHC will continue to promote the IAQ Guide.	EHC sponsored or co-sponsored 4 programs in ORL. EHC sponsored or co-sponsored 2 programs for STL. 4 programs to be submitted for LV The IAQ column in the ASHRAE Journal continues, 5 articles are in the queue.
4	a) Discuss and report on at least a new emerging issue brief related to environmental health and b) review of current emerging issue briefs	30-Jun-16	Baker, Education Subc.	1.1, 1.8	a) A new Emerging issue brief identified for possible development. B) Publish, update or reaffirm existing briefs. 2-3 EIs are expected to be ready by end 2015-2016 (Nanoparticle environmental health and safety, e-cigarettes, and Environmental impact of air cleaning building materials and coatings	EHC approved 2 new EIBs on Nano Environmental Health and Safety (nanoEHS) & Indoor passive panel technologies for air cleaning in buildings. Topics for 2 more possible EIB's have been identified.
5	Continue detailed planning for IAQ 2016. Co-sponsor IAQVEC 2016	30-Sep-16	Bahnfleth (lead), various	1.2, 4.3	This activity has started with Bahnfleth as conference chair, Alexandria VA as location and Sept 2016 as the time of event. Progress is currently on schedule	EHC plans to meet at the IAQ 2016 conference in September
Policy						
6	Support ASHRAE policy relating to EH	30-Jun-16	Policy Subc.	1.1, 1.2	EHC will continue to maintain and produce EH-related position documents and emerging issue briefs. Position documents: Combustion in developing countries is planned to start 2015-2016 year. Legionellosis and IAQ PDs should be completed during the 2015-2016 year. Decision on 2 PDs (ETS and Limiting Indoor Mold Growth and Dampness in Buildings Systems) to be reaffirm, revise or retire. Other PDs are expected to be reaffirmed or do not need any action. Emerging issue briefs, new emerging issues will be identified and briefs will be developed. Policy subcommittee will continue the process started in 2014 of determining which emerging issue briefs should be retained/revised, which should be dropped, and which should be turned into PDs. For those that are elevated to PDs, PD chairs and committees shall be named.	EHC approved a motion in ORL to revise the ETS PD. EHC reaffirmed Limiting Indoor Mold Growth and Dampness in Buildings Systems PD EHC approved 2 EIBs on Nano Environmental Health and Safety (nanoEHS) and Indoor passive panel technologies for air cleaning in buildings. Topics for 2 more possible EIB's have been identified.
Handbook and Publications						
7	Fundamentals, Handbook and ASHRAE-wiki (review and definition of terms)	30-Jul-16	Weekes, Handbook Subc.	1.1, 1.2, 2.1, 3.3	Complete revision of handbook chapter for 2017 edition.	Chapter is finalized and sent to Handbook Committee.
8	Liaison to EH-related Standards and Guidelines	ongoing	Various individuals, see to right	1.1, 1.2, 4.9	Standards 55 Schoen, 62.1 Hedrick, 62.2 Francisco, 188 Lucas, 189.1 Stanke; Guidelines 10 Emmerich, 12 Lucas	EHC continues to receive reports on the various environmental health related standards at each meeting. Assigned member to monitor public review changes to standards affecting environmental health
Administration						
9	Revise committee meeting structure for efficiency	on-going	Exec. Committee	1.1, 1.2	Full committee meetings have included significant re-stating of details from subcommittee meetings. Subcommittee reports will be restructured to focus on items requiring votes, high-level information items, and an opportunity for questions. This will allow a greater amount of time for other issues and ensuring that all topics are addressed.	EHC continues to operate in this format. The Strategic Discussion in ORL focused on DOE Research on Impacts of Weatherization Efforts and resulted in ideas for 1 possible EIB, 3 programs, and 1 research effort. Topic for STL was related to the Physiological impact of CO2 in the Indoor Space.
10	Maintain continuity by making Immediate Past Chair a formal position	30-Jun-16	Vice Chair, Exec. Committee	1.1, 1.2	Revise EHC MOP and propose ROB change -- include Immediate Past Chair as an official member when the immediate past chair has rolled off the committee following their year as chair.	Motion is still with Society Rules Committee

Chair: Zuraimi Sultan
Vice-Chair: Wane Baker
Consultant: Paul Francisco

Subcommittees

Research committee: Siegel (chair), Lucas, Horner, Sultan, Baumgarten
Policy committee: Balaras (chair), Kennedy, Araj, Baker
Handbook committee: Weekes (chair), McCoy
Education/Program committee: Schoen (Chair), Bahnfleth, Francisco, Stanke, Persily,

ASHRAE Position Document on Environmental Tobacco Smoke

Approved by ASHRAE Board of Directors
October 22, 2010

Reaffirmed by ASHRAE Technology Council
June 25, 2013

Expires
June 25, 2016

ASHRAE
1791 Tullie Circle, NE • Atlanta, Georgia 30329-2305
404-636-8400 • fax: 404-321-5478 • www.ashrae.org

Committee Roster

The ASHRAE Position Document on Environmental Tobacco Smoke was originally developed in 2004 by the Society's Environmental Tobacco Smoke Position Document Committee. Their current affiliations are listed below.

Jonathan Samet, MD, MS
University of Southern California Keck School of Public Health
Dept of Preventive Medicine
Los Angeles, Calif.

Hoy R. Bohanon Jr.
Working Buildings
Winston-Salem, N.C.

David B. Coultas, MD
The University of Texas Health Science Center
Tyler, Texas

Thomas P. Houston, MD
OhioHealth Nicotine Dependence Program
at McConnell Heart Health Center
Columbus, Ohio

Andrew K. Persily
National Institute of Standards and Technology
Gaithersburg, Md.

Lawrence J. Schoen
Schoen Engineering Inc.
Columbia, Md.

John Spengler
Harvard University School of Public Health
Boston, Mass.

Cynthia A. Callaway
P2S Engineering Inc.
Long Beach, Calif.

HISTORY OF REVISION/REAFFIRMATION/WITHDRAWAL DATES

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

6/30/2005—BOD approves Position Document titled *Environmental Tobacco Smoke*

6/25/2008—BOD approves reaffirmation of Position Document titled *Environmental Tobacco Smoke*

10/22/2010—BOD approves revision to Position Document titled *Environmental Tobacco Smoke*

6/30/2013—Technology Council approves reaffirmation of Position Document titled *Environmental Tobacco Smoke*

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

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

Executive Summary

This position document has been written to provide the membership of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and other interested persons with information on the health consequences of exposure of nonsmokers to tobacco smoke in indoor environments, and on the implications of this knowledge for the design, installation and operation of heating, ventilating, and air-conditioning (HVAC) systems. ASHRAE's sole objective is to advance the arts and sciences of heating, refrigeration, air conditioning and ventilation, and their allied arts and sciences and related human factors, for the benefit of the public. Therefore, the health effects of indoor exposure to emissions from cigarettes, cigars, pipes, and other tobacco products have long been relevant to ASHRAE.

For more than three decades, researchers have investigated the health and irritant effects among non-smokers exposed to tobacco smoke in indoor environments. The preponderance of credible evidence links passive smoking to specific diseases and other adverse health effects in people. A number of national and global review groups and agencies have concluded that exposure of nonsmokers to tobacco smoke causes adverse effects to human health. No cognizant authorities have identified an acceptable level of environmental tobacco smoke (ETS) exposure, nor is there any expectation that further research will identify such a level.

International experience has been gained over several decades with using various strategies to reduce ETS exposure, including separation of smokers from nonsmokers, ventilation, air cleaning and filtration, and smoking bans. Only the last provides the lowest achievable exposures for nonsmokers and is the only effective control method recognized by cognizant authorities (see *Findings of Cognizant Authorities* below). At the time of this writing, several nations[1,2], 30 states[3] in the U.S. and hundreds of municipalities and other jurisdictions have banned tobacco smoking completely in all public buildings and workspaces. The U.S. government has banned smoking in its workplaces. Experience with such bans documents that they can be effective, practically eliminating ETS exposure of non-smokers. The benefits of bans, including exposure reduction and benefits to public health are well documented[4,5]. While exposure is decreasing internationally because of these smoking bans in public and private buildings, and a decrease in the prevalence of smoking, substantial portions of the population are still regularly exposed in workplaces, homes and public places, such as entertainment venues.

ASHRAE concludes that:

- It is the consensus of the medical community and its cognizant authorities that ETS is a health risk, causing lung cancer and heart disease in adults, and exacerbation of asthma, lower respiratory illnesses and other adverse effects on the respiratory health of children.
- At present, the only means of effectively eliminating health risk associated with indoor exposure is to ban smoking activity.
- Although complete separation and isolation of smoking rooms can control ETS exposure in non-smoking spaces in the same building, adverse health effects for the occupants of the smoking room cannot be controlled by ventilation.

- No other engineering approaches, including current and advanced dilution ventilation or air cleaning technologies, have been demonstrated or should be relied upon to control health risks from ETS exposure in spaces where smoking occurs. Some engineering measures may reduce that exposure and the corresponding risk to some degree while also addressing to some extent the comfort issues of odor and some forms of irritation. However, the public now expects smoke-free air which cannot be accomplished with any engineering or other approaches.
- An increasing number of local, state, and national governments, as well as many private building owners, are adopting and implementing bans on indoor smoking.
- At a minimum, ASHRAE members must abide by local regulations and building codes and stay aware of changes in areas where they practice, and should educate and inform their clients of the substantial limitations and the available benefits of engineering controls.
- Because of ASHRAE's mission to act for the benefit of the public, it encourages elimination of smoking in the indoor environment as the optimal way to minimize ETS exposure.

1.0 Introduction

Providing healthful and comfortable indoor environments through the control of indoor air quality is a fundamental goal of building and HVAC design and operation. ASHRAE has long been active in providing engineering technology, standards and design guidance in support of this goal. These activities are consistent with the society's Certificate of Consolidation, which states that ASHRAE's sole objective is "… to advance the arts and sciences of heating, refrigeration, air conditioning and ventilation, and their allied arts and sciences and related human factors, for the benefit of the public."

This position document has been written to provide the membership of ASHRAE and other interested persons with information on what is known about the health consequences to nonsmokers from exposure to tobacco smoke in indoor environments and on the implications of this knowledge for the design, installation and operation of HVAC systems. Because tobacco smoke is a source of both gaseous and particulate contaminants, the health effects of inhaling smoke from cigarettes, cigars, pipes, or other tobacco products in indoor environments have long been relevant to ASHRAE, and specifically to ASHRAE Standard 62.1, *Ventilation for Acceptable Indoor Air Quality*[6].ASHRAE continues to re-affirm its policy stating that while "ASHRAE does not make findings as to the health and safety impacts of environmental exposures," its document and activities "shall consider health and safety impacts."[7,8] Therefore, it is important for ASHRAE to identify these impacts as they relate to the activities of its members and then to consider them in its documents, as it has done in ASHRAE Standard 62.1. ASHRAE also adopted a policy stating that ASHRAE standards and guidelines will not set ventilation requirements and will not claim to provide acceptable indoor air quality in smoking spaces. Note that this policy does not prevent ASHRAE from providing guidance for designing smoking spaces in other documents, but these documents would only address odor and other comfort goals.

Concerns regarding tobacco smoke in indoor environments have arisen from evidence of adverse health and irritation effects caused among nonsmokers exposed to tobacco smoke indoors. The relevant evidence comes from information on tobacco smoke and its components; from toxicologic studies of tobacco smoke and some of its specific components; from the substantial epidemiologic, pathologic, and clinical evidence that shows the health effects of active smoking; and from epidemiologic studies that have assessed the risks of passive smoking. The latter studies, carried out over the last three decades, have linked passive smoking to specific diseases and other adverse health effects in children and adults.

There are now several decades of international experience with the use of various strategies to reduce ETS exposure, including separation of smokers and nonsmokers, ventilation, air cleaning and filtration, and bans. Only the last provides the lowest achievable exposures for nonsmokers and experience with such bans documents that they can be effective[2,9]. While exposure is decreasing nationally because of these smoking bans in public and private buildings, and because of decreases in the prevalence of smoking, substantial portions of the population are still regularly exposed in workplaces, homes, and public places, such as entertainment venues.

2.0 Tobacco Smoke in Indoor Spaces: Characteristics and Concentrations

2.1 Characteristics of tobacco smoke in indoor spaces

While tobacco may be smoked in other forms (e.g., pipes and cigars), the cigarette is the principal source of exposure of nonsmokers to tobacco smoke in the United States and other countries. The burning cigarette produces smoke primarily in the form of mainstream smoke (MS) -- that smoke inhaled by the smoker during puffing -- and sidestream smoke (SS) -- that smoke released by the smoldering cigarette while not being actively smoked. Because of the lower temperature in the burning cone of the smoldering cigarette, many tobacco combustion products are enriched in SS compared to MS.

Nonsmokers are exposed to the combination of diluted SS that is released from the cigarette's burning end and the MS exhaled by the active smoker[8]. This mixture of diluted SS and exhaled MS has been referred to as secondhand smoke or environmental tobacco smoke (ETS); the term used in this position document. Exposure to ETS is also commonly referred to as passive or involuntary smoking.

Tobacco smoke consists of a complex mixture of particles and gases, with thousands of individual chemical components. The particles in ETS are in the submicron size range, and as such, penetrate deeply into the lung when inhaled. The respiratory tract (which extends from the nose to the alveoli) absorbs the gases in a manner dependent on their chemical and physical characteristics. For example, reactive and highly soluble gases, such as formaldehyde, are adsorbed in the upper respiratory tract, while less soluble and more inert gases, such as carbon monoxide, reach the alveoli and may be systemically absorbed. Additionally, these particles and gases also impact the mucous membranes of the eyes. While exposures of involuntary and active smoking differ quantitatively and, to some extent, qualitatively [9, 11-16], involuntary smoking results in exposure to multiple toxic agents including known human carcinogens generated by tobacco combustion[9,11-17].

2.2 Exposure to tobacco smoke in indoor spaces

The concentration of the various ETS constituents in an indoor space depends on the number of smokers and their pattern of smoking, the volume of the space, the ventilation rate and the effectiveness of the air distribution, the rate of removal of ETS from the indoor air by air cleaners, deposition of particles onto surfaces, and surface adsorption and re-emission of gaseous components. Because ETS is a complex mixture, measurements of single components are of varying specificity and none alone is considered to indicate the potential toxicity of ETS at a particular concentration. Therefore, measurements of multiple surrogates have been used as indicators of the concentration of the mixture for research and public health purposes. These measures include respirable suspended particles (RSP), nicotine, benzene, solanesol, 3-ethenyl pyridine (3-EP) and carbon monoxide. Such measurements have demonstrated contamination of indoor air wherever smoking takes place. Biomarkers of ETS exposure, i.e., indicators in biological materials such as nicotine in saliva and blood, have also been measured; measurable concentrations of these biomarkers (e.g. cotinine) have been found in the bodies of exposed nonsmokers, indicating uptake of ETS.

3.0 Health Effects of Involuntary Smoking

3.1 Cognizant authorities

Following the same approach used in the landmark 1964 report of the U.S. Surgeon General on smoking and health, the finding that involuntary smoking causes disease or other adverse effects has been based in systematic review of the evidence and the application of criteria for evaluating the strength of evidence in support of causality. The principles for causal inference were set out in the 1964 report and revisited in the subsequent reports of the Surgeon General[9,18,19]. This approach for evidence evaluation involves systematically gathering and assessing the quality of individual research studies, and then evaluating the overall strength of evidence using accepted causal criteria as guidelines. The term *causal criteria* refers to a set of principles for evaluating evidence for causal inference. These criteria include the consistency of the evidence, the strength of the association of involuntary smoking with the health outcome of concern, the specificity of that association, proper temporality of the association (i.e., involuntary smoking proceeds onset of the health outcome), and the coherence of the evidence.

Using this general approach, the scientific evidence on the health consequences of exposure to ETS has been extensively reviewed by a number of independent expert groups (cognizant authorities) in the United States and internationally, with similar conclusions over the last two decades (Table 1). In the United States, five major cognizant authorities have examined the evidence, including the U.S. Surgeon General[9,15], the U.S. Environmental Protection Agency[16], the National Research Council[13], the California Environmental Protection Agency[20-22] , and the National Toxicology Program[23]. The first major reviews were published in 1986[15,32]. As the evidence has expanded, further reviews have been carried out in the United States and internationally. These conclusions are also supported by positions of major health organizations, such as the American Cancer Society, the American Heart Association, the American Lung Association, the American Medical Association, and the British Medical Association, and many professional societies, such as the American Public Health Association, the American Thoracic Society, the American College of Preventive Medicine, the American Academy of Pediatrics and others.

The validity of the conclusions from these cognizant authorities is largely based on the integrity of the processes used to ensure that the reviews and conclusions are free of bias. Factors used to assess the potential role of bias in these processes include the expertise and independence of the report's authors and reviewers, the comprehensiveness of the approach to reviewing the scientific evidence, and the process for peer-review of the report.

3.2 Findings of Cognizant Authorities

Scientific evidence indicates adverse health effects from passive smoking throughout the life-span (Table 1). Some of the first epidemiological studies on ETS and health were reported in the late 1960s[24-26] and since then there have been hundreds of scientific papers on the health effects of ETS exposure. Exposure to ETS in actual indoor spaces has since been linked to numerous adverse effects in infants and children. The adverse effects may even extend to gestation, as ETS components and metabolites reach the fetus of pregnant mothers who are exposed. There is evidence suggesting that ETS exposure of the mother reduces birth weight and that child development and behavior are adversely affected by parental smoking[27,28]. ETS exposure causes increased risk for more severe lower respiratory infections, middle ear disease, chronic respiratory symptoms and asthma, and reduces the rate of lung function growth during childhood. There is no strong evidence at present that ETS exposure increases childhood cancer risk[29].

The first major studies on passive smoking and lung cancer in non-smoking adults were reported in 1981 [30,31] and by 1986[15,32] the evidence supported the conclusion that passive smoking was a cause of lung cancer in non-smokers. Subsequent evidence has continued to identify other diseases and adverse effects of passive smoking in adults, and the conclusion has been reached that coronary heart disease is caused by ETS exposure (Table 1). The number of coronary heart disease deaths caused by ETS greatly exceeds the number of ETS-caused lung cancer deaths.

Thus, the epidemiological evidence, along with the other relevant lines of evidence, has been reviewed periodically by cognizant authorities with an increasingly lengthy list of diseases and other adverse effects associated with ETS exposure in the nearly two decades since the first causal conclusions were reached in 1986[15,32]. Notably, conclusions offered by the cognizant authorities have converged and no conclusions have ever been reversed. The conclusions of these studies refer to ETS exposure in general since the biological action does not depend on the particular type of indoor environments.

The reports and their conclusions have not indicated that thresholds can be identified below which effects would not be anticipated, and in general, risks tend to increase with the level of exposure and conversely to decrease with a reduction in exposure. On a biological basis, a threshold would not be anticipated for the carcinogens in ETS [(22;25).] Additionally, the scientific evidence recognizes substantial subpopulations potentially susceptible to ETS, such as children and adults with asthma or heart disease, whose disease may be exacerbated by ETS exposure.

In the absence of a quantitative criterion for acceptable exposure, the only protective measure for effective control that has been recognized by cognizant authorities is an indoor smoking ban, leading to near zero exposure.

4.0 Considerations Related to HVAC System Design and Operation

4.1 General principles

Societal recognition of the public health risks to children and adults of ETS exposure has motivated the use of strategies to reduce or eliminate exposure to ETS. Exposure to ETS has been reduced through a variety of strategies, including those that reduce, but do not eliminate, exposure to ETS. Others, such as banning or restricting smoking, result in a complete or nearly complete reduction of exposure to ETS. The specific strategies may be regulatory or voluntary in their application. Because smoking is a strong localized source of a complex mixture of hazardous agents with different physical and chemical characteristics, multiple engineering techniques need to be employed to minimize ETS exposure in non-smoking areas, absent a smoking ban. There is no target for such reduction, as no cognizant authority has defined a safe level of ETS exposure because of the complex nature of ETS, the multiple health and irritation hazards, and varying individual susceptibility to ETS.

Practitioners must always follow the laws and regulations in laws, regulations and directives at all levels of government, as well as industry codes and standards. Even where permitted by law, many developers, building owners, and operators do not allow smoking. For instance, the Building Owners and Managers Association (BOMA) International has taken the position that secondhand smoke should not be allowed in buildings and supports legislation to ban smoking in buildings[33]. In the U.S. and many other countries as well, smoking has been banned in most office buildings, shopping center common areas and in most retail sales areas. Many operators of restaurants and other hospitality venues have voluntarily done the same. Therefore, it is recommended that engineers work with their clients to define their intent for addressing ETS exposure in their building. In working with their clients, engineers need to take account of all laws and regulations relevant to ETS, and with their clients develop a strategy that will result in the lowest ETS exposure to building occupants within the context of a building's intended use.

4.2 Design and Operation Approaches

There are four general cases of space-use and smoking activity that lead to different engineering approaches to addressing ETS exposure in buildings: 1) banning smoking indoors; 2) allowing smoking only in isolated rooms; 3) allowing smoking in separate but not isolated spaces; and 4) totally mixing occupancy of smokers and nonsmokers. These approaches do not necessarily account for all circumstances, but are in a sequence from most to least effective in controlling ETS exposure.

1. **Banning Smoking Indoors:** A total ban on indoor smoking is the only effective means of controlling the health risks associated with ETS exposure. This approach has been implemented by many governments and private building owners. While there are no system design issues related to this approach, the existence of outdoor smoking areas near the building and their potential impacts on entryway exposure and outdoor air intake locations should be discussed with the developer, building owner, and/or building operator.

2. **Smoking Only in Isolated Rooms:** Allowing smoking only in separate and isolated rooms, typically dedicated to smoking, can control ETS exposure in non-smoking spaces in the same building. Effective isolation is achievable through airflow and pressure control including location of supply outlets and return and exhaust air inlets to preserve desirable airflow directions at doorways, as well as the use of separate ventilation systems serving the smoking spaces. When using this approach, the design and operation need to address entrainment of exhaust air containing ETS into the non-smoking area's system through the air intake, windows, and other

airflow paths. In addition, the airtightness of the physical barriers between the smoking and nonsmoking areas, as well as of the connecting doorways, requires special attention. Some smoking lounges in airports or office buildings exemplify use of this control approach. The risk of adverse health effects for the occupants of the smoking room cannot be controlled by ventilation. Engineering techniques to reduce odor and irritation in the smoking room include dilution ventilation, and air cleaning and filtration techniques.

3. **Smoking in Separate But Not Isolated Spaces:** In the third situation, smoking is allowed in separate spaces that are not physically isolated from non-smoking areas. This approach includes spaces where smokers and non-smokers are separated but still occupy a single space or a collection of smoking and non-smoking spaces served by the same air handler. Examples can be found in restaurants and bars with smoking and non-smoking areas, or buildings where smoking is restricted to specific rooms but a common, recirculating air handler serves both the smoking and non-smoking rooms. This situation also includes spaces where a common air handler does not recirculate from the smoking to the nonsmoking area and spaces with multiple air handlers.

Engineering techniques to reduce odor and irritation include, directional airflow patterns achieved through selective location of supply and exhaust vents, and air cleaning and filtration. These techniques may reduce ETS exposure in non-smoking areas but limited evidence is available on their effectiveness. Movement of people between non-smoking and smoking areas may disrupt intended airflow patterns, degrading the effectiveness of exposure reduction for the non-smoking occupants (including workers).

4. **Mixed Occupancy of Smokers and Nonsmokers:** If smoking is allowed throughout a space or a collection of spaces served by the same air handler, with no effort to isolate or separate the smokers and nonsmokers, there is no currently available or reasonably anticipated ventilation or air cleaning system that can adequately control or significantly reduce the health risks of ETS. For example, this situation includes unrestricted smoking in homes, dormitories, casinos, bingo parlors, small workplaces, and open plan office spaces. Air cleaning, ordinary dilution ventilation and displacement ventilation can provide some reduction in exposure but they cannot minimize adverse health effects, nor odor and sensory irritation for nonsmokers in general.

5.0 Conclusions

- There is a consensus among cognizant medical authorities that ETS is a health risk, causing lung cancer and heart disease in adults, and causing adverse effects on the respiratory health of children, including exacerbating asthma and increasing risk for lower respiratory tract infection.
- At present, the only means of eliminating health risks associated with indoor exposure is to ban all smoking activity.
- Although complete separation and isolation of smoking rooms can control ETS exposure in non-smoking spaces in the same building, adverse health effects for the occupants of the smoking room cannot be controlled by ventilation.

- No other engineering approaches, including current and advanced dilution ventilation, “air curtains” or air cleaning technologies, have been demonstrated or should be relied upon to control health risks from ETS exposure in spaces where smoking occurs, though some approaches may reduce that exposure and address odor and some forms of irritation.
- An increasing number of local and national governments, as well as many private building owners, are implementing/adopting bans on indoor smoking.
- At a minimum, ASHRAE members must abide by local regulations and building codes and stay aware of changes where they practice; they should also educate/inform their clients of the limits of engineering controls in regard to ETS.
- Because of ASHRAE’s mission to act for the benefit of the public, it encourages elimination of smoking in the indoor environment as the optimal way to control ETS exposure.

Table 1. Adverse Effects from ETS Throughout the Life Span

Health Effect	SG 1984[14]	SG 2006[9]	EPA 1992[16]	CalEPA 2005[22]	UK 1998[34]	WHO 1999[35]	IARC 2002[29]
Children							
Risk factor for SIDS		Yes/c		Yes/c	Yes/a	Yes/c	
Increased prevalence of respiratory illnesses	Yes/a	Yes/c	Yes/c	Yes/c	Yes/c	Yes/c	
Decrement in pulmonary function	Yes/a	Yes/c	Yes/a	Yes/c		Yes/c	
Increased frequency of bronchitis, pneumonia	Yes/a	Yes/c	Yes/a	Yes/c		Yes/c	
Increase in chronic cough, phlegm		Yes/c		Yes/c		Yes/c	
Increased frequency of middle ear effusion		Yes/c	Yes/c	Yes/c	Yes/c	Yes/c	
Increased severity of asthma episodes and symptoms		Yes/c	Yes/c	Yes/c		Yes/c	
Risk factor for new asthma		Yes/a	Yes/a	Yes/c			
Low Birth Weight		Yes/c		Yes/c			
Adults							
Risk factor for lung cancer		Yes/c	Yes/c	Yes/c	Yes/c	Not addressed	Yes/c
Risk factor for breast cancer		Yes/a		Yes/c			
Risk factor for heart disease		Yes/c		Yes/c	Yes/c	Yes/a	
Respiratory symptoms and lung function	Yes/a	Yes/a		Yes/c			
Increased severity of asthma episodes and symptoms		Yes/a		Yes/c			

Yes/a = association

Yes/c = cause

6.0 CITATIONS

1. World Health Organization. 2008. Report on the Global Tobacco Epidemic. Geneva, Switzerland.

2. World Health Organization. 2007. Protection from exposure to second-hand tobacco smoke. Policy recommendations, Geneva, Switzerland.

3. Americans for Nonsmokers Rights Foundation. Table: States, Commonwealths and Municipalities with 100% Smokefree Laws in Workplaces, Restaurants, or Bars. http://www.no-smoke.org/pdf/100ordlist.pdf accessed September 3,. 2010

4. Centers for Disease Control. 2010 "Morbidity and Mortality Weekly Reports (MMWRs) Vital Signs: Nonsmokers' Exposure to Secondhand Smoke - United States, 1999-2008". September 10, 2010 / Vol. 59 / No. 35. Atlanta, Ga.

5. Mackay, DF, Irfan, MO, Haw, S et al. 2010. Meta-analysis of the effect of comprehensive smoke-free legislation on acute coronary events. Br. Med J (Heart) 96:1525-1530

6. ASHRAE. 2010. Standard 62.1-2010- Ventilation for Acceptable Indoor Air Quality, Atlanta, Ga.

7. ASHRAE. 2000. Presidential Ad Hoc Committee on Health Impacts in Standards ("Bellenger Report "), Atlanta, Ga.

8. ASHRAE. 2005. Ad Hoc Committee on Health Effects Final Report ("Burgett Report"), Atlanta, Ga. (Also see ASHRAE's Rule of the Board ROB 110-116-006)

9. U.S. Department of Health and Human Services. 2006. *The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General.* Centers for Disease Control and Prevention, Coordinating Center for Health Promotion, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. Atlanta, Ga.

10. First, MW. 1985. Constituents of sidestream and mainstream tobacco and markers to quantify exposure to them. In: Indoor air and human health (Gammage RB, ed). Lewis Publishers, Chelsea, Mi

11. Jenkins, RA, MR Guerin, BA Tomkins. 2000. The chemistry of environmental tobacco smoke: composition and measurement (2nd ed.). Boca Raton, Lewis Publishers

12. National Research Council (NRC), 1981. Committee on Indoor Pollutants. Indoor pollutants. National Academy Press, Washington, D.C.

13. National Research Council (NRC), 1986. Committee on Passive Smoking. Environmental tobacco smoke: Measuring exposures and assessing health effects. National Academy Press Washington, D.C.

14. US Department of Health and Human Services (USDHHS). 1984. The health consequences of smoking -- chronic obstructive lung disease. A report of the Surgeon General. U.S. Government Printing Office, Washington, D.C.

15. US Department of Health and Human Services (USDHHS). 1986 The health consequences of involuntary smoking: A report of the Surgeon General. DHHS Publication No. (CDC) 87-8398. U.S. Government Printing Office, Washington, D.C.

16. US Environmental Protection Agency (EPA). 1992. Respiratory health effects of passive smoking: Lung cancer and other disorders. EPA/600/006F. U.S. Government Printing Office, Washington, D.C.

17. U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program. 2005. Report on Carcinogens, Eleventh Edition. http://ntp.niehs.nih.gov/index.cfm?objectid=32BA9724-F1F6-975E-7FCE50709CB4C932.

18. US Department of Health Education and Welfare (DHEW). 1964. Smoking and health. Report of the Advisory Committee to the Surgeon General. DHEW Publication No. [PHS] 1103. U.S. Government Printing Office, Washington, D.C.

19. US Department of Health and Human Services (USDHHS). 2004. The health consequences of smoking: A report of the Surgeon General. U.S. Government Printing Office, Washington, D.C.

20. California Environmental Protection Agency (Cal EPA). 1997.Office of Environmental Health Hazard Assessment. Health Effects of Exposure to Environmental Tobacco Smoke. California Environmental Protection Agency.

21. California Environmental Protection Agency (Cal EPA). 2003. Proposed identification of environmental tobacco smoke as a toxic air contaminant, November 2003. California Environmental Protection Agency, Sacramento, CA.

22. California Environmental Protection Agency (Cal EPA). Scientific Review Panel 2005. Proposed Identification of Environmental Tobacco Smoke as a Toxic Air Contaminant Part B: Health Effects Assessment for Environmental Tobacco Smoke.

23. National Toxicology Program (NTP). 2000. Report on Carcinogens, Ninth Edition. Research Triangle Park, NC: US Department of Health and Human Services (USDHHS).

24. Cameron, P. 1967. The presence of pets and smoking as correlates of perceived disease. J Allergy 67: 12-15.

25. Cameron P, JS Kostin, JM Zaks, JH Wolfe, G Tighe, B Oselett, R Stocker, J Winton. 1969. The health of smokers' and nonsmokers' children. J Allergy 43: 336-341.

26. Colley, JR, WW Holland. 1967. Social and environmental factors in respiratory disease. A preliminary report. Arch Environ Health 67: 157-161.

27. Eskenazi, B, R Castorina. 1999. Association of prenatal maternal or postnatal child environmental tobacco smoke exposure and neurodevelopmental and behavioral problems in children. WHO/NCD/TF1/99.11.

28. World Health Organization. 1999. International Consultation on Environmental Tobacco Smoke (ETS) and Child Health. Consultation Report. World Health Organization, Geneva.

29. International Agency for Research on Cancer (IARC). 2002. Tobacco smoke and involuntary smoking. IARC monograph 83. [83]. International Agency for Research on Cancer. Lyon, France.

30. Hirayama T. 1981. Non-smoking wives of heavy smokers have a higher risk of lung cancer: A study from Japan. Br Med J (Clin Res Ed) 282:183-185.

31. Trichopoulos, D, A. Kalandidi, L. Sparros, B MacMahon. 1981 Lung cancer and passive smoking. Int J Cancer 27:1-4.

32. International Agency for Research on Cancer (IARC). 1986. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans: Tobacco Smoking. [Monograph 38]. 1986. World Health Organization Lyon, France.

33. Building Owners and Managers Association (BOMA). Smoking In Office Buildings. BOMA position. www.boma.org/Advocacy/FederalLegislativeRegulatoryIssues/Environment/SmokingInOfficeBuildings.htm.

34. Scientific Committee on Tobacco and Health and HSMO. 1998. Report of the Scientific Committee on Tobacco and Health. The Stationary Office. 1998; 011322124x

35. WHO. 1999. International Consultation on Environmental Tobacco Smoke (ETS) and Child Health. Consultation Report. World Health Organization. Geneva, Switzerland.

ASHRAE Multidisciplinary Task Group: Damp Buildings

Final Report - Tuesday, June 14, 2016

SUMMARY AND RECOMMENDATIONS

Epidemiological investigators have shown clear and consistent associations between occupancy of damp indoor spaces and increased probability of important adverse health effects such as development of new asthma, exacerbation of existing asthma, allergic rhinitis, and respiratory infections[1] (Institute of Medicine 2004, WHO 2009, Mendell, Mirer et al. 2011, Miller 2011, Kennedy et al 2013, Miller 2014, Kanchongkittiphon, Mendell et al. 2015). Unlike some other health risks, illnesses triggered by damp indoor spaces are preventable.

In response to the ASHRAE Board-Approved Position Document on indoor mold, ASHRAE's Technical Activities Committee (TAC) authorized the creation of this multidisciplinary task group (MTG) to develop a simple and easily recognizable description of dampness that is sufficient to increase the probability of negative health effects, and to suggest practical quantitative tools and techniques that can alert managers to the risk of a building or an indoor space becoming "damp" to an extent that affects health in the future.

Towards these ends, our task group has reached consensus recommendations for a description of health-relevant indoor dampness, and for quantitative tests and thresholds that can serve as early warning signs of possible health-relevant dampness in the future. These include:

1. **Health-relevant indoor dampness:** Indicators of health-relevant indoor dampness in a building or space include visible mold growth, damage from water or moisture, or musty/moldy/earthy odors. These indicators have each been clearly and strongly associated with increased probability of negative health effects for occupants, although no specific dampness thresholds have been established, and not all individuals are equally affected.
2. **Quantitative metrics, with thresholds that separately provide *early warning* of possible future health-relevant dampness:**
    a. Persistent water activity levels above 0.75 at the surfaces of organic materials or coatings.
    b. Persistent moisture content above 15% wood moisture equivalent (WME) in organic materials, coatings and untreated paper-faced gypsum board.
    c. Persistent moisture content above 80% equilibrium RH in concrete or masonry that is either coated with—or is in contact with—organic materials or coatings.
    d. Persistent indoor humidity above a dew point temperature of 60°F (15°C) in buildings that are being mechanically cooled, or above a dew point temperature of 45°F (7°C) in buildings that are being heated.

In this context, the word "persistent" means that the condition has become typical, because it extends for days or weeks at a time, rather than being infrequent excursions of a few hours per week above these suggested thresholds, followed by a return to normal levels of dryness.

Note that *any* of these are indicators of abnormal conditions that can ultimately lead to moisture accumulation and health-relevant indoor dampness. The word "abnormal" is used here to describe conditions that, while they may occur with some regularity in many buildings, are seldom if ever the basis of design for durable buildings and energy-efficient climate control systems.

---

[1] Evidence from epidemiologic studies showed indoor dampness or mold were consistently associated with increases in multiple diseases (asthma development, asthma exacerbation, current asthma, ever diagnosed asthma, respiratory infections, allergic rhinitis, eczema, and bronchitis) and symptoms (lower respiratory symptoms such as difficulty breathing and wheeze; upper respiratory tract symptoms such as nasal, sinus, and throat symptoms, and cough) (Mendell , Mirer et al. 2011).

Finally, note also that these metrics and thresholds are not intended to be, nor have they been documented to be, indicators of *current* health-relevant indoor dampness. The description above satisfies that purpose. Unless or until such associations are established and documented, these quantitative metrics should be considered *early warnings* of possible health-relevant dampness at some future date. They do not provide quantitative validation of current health-relevant dampness.

3. Dampness leading to structural risk

This report deals with the issue of dampness as it relates to human health. But our committee notes that excessive indoor dampness has also been documented to reduce the load-bearing capacity of wood framing. Further, extended dampness or periodic condensation can corrode critical structural fasteners inside the walls, foundation and roof of a building.

Under those circumstances, problems associated with excessive indoor dampness go far beyond long-term health effects, extending all the way to the risk of short-term structural failure. A thorough discussion of structural risks is beyond the scope of our committee's assignment. But we note the importance of limiting moisture accumulation and avoiding condensation not only inside the building, but also inside the assemblies of its exterior walls, foundation and roof. Prudent building design, construction and management must avoid interstitial condensation and moisture accumulation.

Periodic moisture content measurements and/or continuous monitoring of moisture content and condensation inside building assemblies can help alert the building owner, allowing action to avoid problems that could proceed to the level of structural failure, with its obvious and significant risks to public health and safety.

DISCUSSION

Our task group notes that persistent dampness is not a normal indoor condition. Indoor spaces and furnishings are designed, constructed and operated to be dry and to stay dry. If an indoor space has become damp enough to grow visible amounts of mold, or to create musty/earthy odors, or to have visible water damage, something about the way the building is designed, constructed, operated or maintained is simply wrong. The sources and mechanisms that led to persistent dampness must be discovered and eliminated promptly to avoid increased probability of health risks to occupants.

Foundation of the Description

The description of the characteristics of health-relevant dampness is based on field research by epidemiological investigators that shows clear relationships between these dampness/mold indicators and negative health effects. In addition, investigations show a dose-response relationship between the *amount* of the dampness/mold indicator and the probability of adverse health effects. As examples of this research, consider the evidence summarized in figures 1 and 2.(Mendell and Kumagai 2016; Kanchongkittiphon, Mendell et al. 2015).

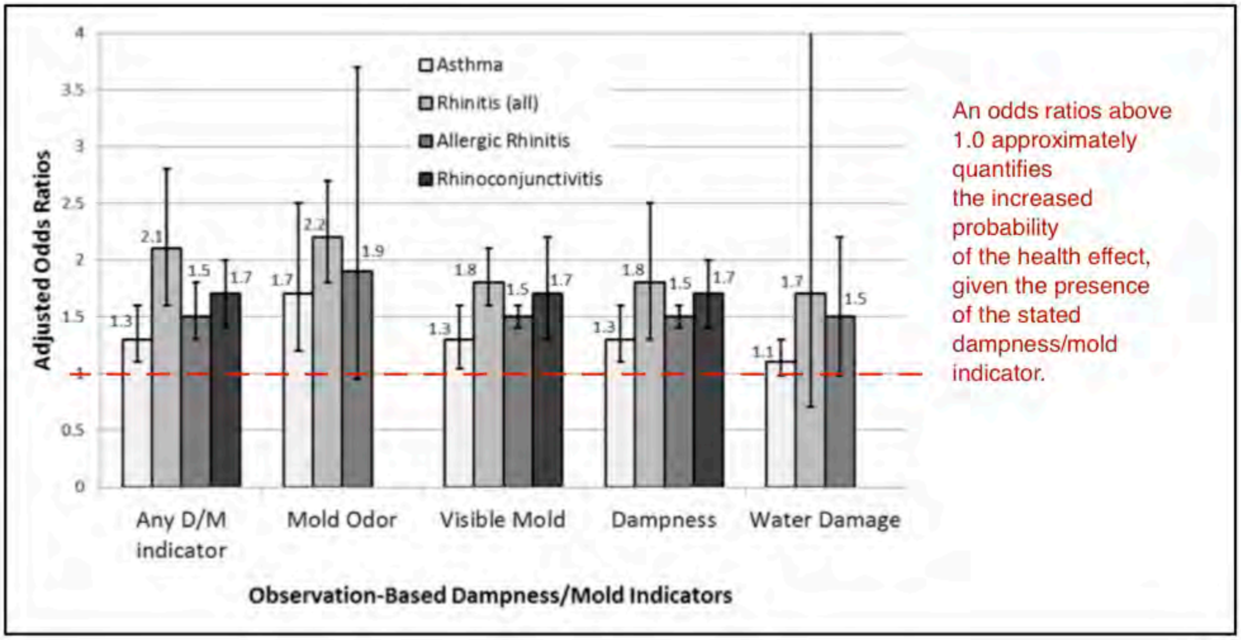

Figure 1. *Summarized findings from data described in two meta-analyses of associations between health effects and dichotomous scores for dampness/mold (D/M) indicators (Quansah, Jaakkola et al. 2012), (Jaakkola, Quansah et al. 2013) Vertical bars show 95% confidence limits. An odds ratio of 1.0 indicates no increased risk with the presence of the dampness/mold indicator. Odds ratios above 1.0 indicate increased probability of the heath effect. This graphic was provided for the purposes of this report by task group member M. Mendell.*

Figure 1 summarizes findings from two quantitative summaries (Quansah, Jaakkola et al. 2012) ((Jaakkola, Quansah et al. 2013) of many studies. The first group of four columns shows that, with any indicator of mold or dampness, the asthma odds ratio (OR) increases to 1.3. In other words, the results show that the probability of developing asthma in previously unaffected occupants increased by about 30% in the presence of any indicator of dampness or mold. Further, the probability of developing any form of rhinitis increased by 110%, and the probability of rhinoconjunctivitis increases by 70%.

The fourth column grouping shows the association established by this research between perceived “dampness” and negative health effects. We note, however, that the studies do not provide any means of quantifying the *amount* of perceived dampness that was associated with those health effects.

Figure 1 also shows that increases in probability indicated by the presence of mold odor (column grouping 2) is greater than the risks associated with the other indicators: visible mold growth, dampness, or water damage (Column groupings 3,4 and 5). From evidence such as this, we conclude that professionals should not dismiss moldy/musty odors as merely indicators of a potential future problem. Instead, those in a position to take action should recognize that odors are an indicator that the probability of negative health effects is already elevated.

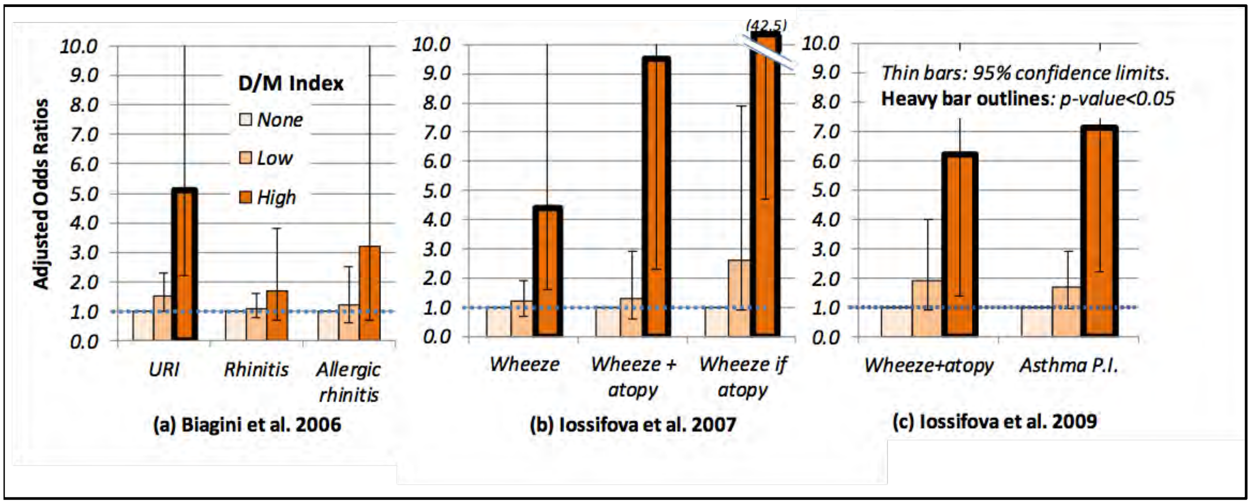

Figure 2. *Summarized associations between health effects and 3-level scores for mold and dampness in the Cincinnati Childhood Allergy and Air Pollution Study (CCAAPS), reported in three articles (Biagini et al. 2006; Iossifova et al. 2007 and 2009). This graphic was provided for the purposes of this report by task group member M. Mendell.*

Next, consider the elevated probability of health effects shown by the three field studies summarized in Figure 2. In these studies, four easily perceptible indicators of dampness or mold were used to establish a mold/dampness index:

1. Visible mold
2. Mold odor
3. Current water damage
4. History of visible mold or water damage

The researchers established three levels for their M/D index: none, low and high. The criterion for an index score of "none" was that *none* of the four indicators of dampness or mold (visible mold, water damage, moisture, or mold odor) were present in the buildings in question. The general level of negative health effects for this group, without the presence of dampness/mold indicators, was considered the reference level, with an odds ratio of 1.0.

The criterion for an index score of "low" was the presence of at least one of the four indicators, but not as much as the surface area amount specified for an index score of "high."

The criterion for an index score of "high" was a total of *EITHER* visible mold greater than or equal to 0.2 m^2 in one room, *OR* visible mold growth plus water damage greater than or equal to 0.2 m^2 on one *surface. (*0.2 m^2 = 2.15 ft^2)

To understand the implications of these results, consider the increase in odds ratio for upper respiratory infections (URI) shown in study a. (Biagini et al 2006). Researchers found approximately five times the odds of having an upper respiratory infection (400% increase in probability) in the presence of *EITHER* visible mold greater than or equal to 0.2 m^2 in one room, *OR* visible mold growth plus water damage greater than or equal to 0.2 m^2 on one *surface. (*0.2 m^2 = 2.15 ft^2).

Also note another important point about the findings shown in the 3-column grouping for "wheeze" from Iossifova 2007 (Figure 2, column grouping b.) The second and third columns in that set of three show that the odds ratios for developing wheeze among all the children in the study at the low and high levels of dampness were 1.2 and 4.4 (20% to 410% increase), compared to column one (no dampness).

But even far greater effects from dampness were seen among the children who were atopic (allergic). These observations are shown in the third set of columns within Figure 2(b). Note that the third set of columns, labeled “wheeze if atopic,” shows that odds ratios for wheeze increased between 2.6 and 42.5. Thus, in this sensitive population, even the low dampness level was associated with a 160% increase, and at the high dampness level the resulting probability of wheeze was almost *10 times* the probability of that negative effect (i.e., 42.5 vs. 4.5) compared to dampness effects on children who were not reported as being allergic at the time of the investigations.

From evidence such as this, we conclude that professionals should not dismiss relatively small amounts of mold growth in one or two parts of a building as merely indicators of a potential future problem. Instead, those in a position to take action should recognize that even relatively small areas of visible mold or water damage (no threshold yet determined) and/or perceptible moldy odors are associated with large increases in probability of negative health effects, for at least some percentage of the public.

FACTORS THAT MAY INCREASE OR REDUCE DAMPNESS HEALTH RISKS

While these epidemiological investigations clearly show elevated probability of negative health effects in spaces that have visible mold, water damage, or moisture or that smell moldy, we note that the research does not confirm equal probability for all people and all types of occupancies. Factors outside of our recommended description may also increase or reduce risks for specific buildings and specific individuals, such as:

Exposure

The peer-reviewed research that establishes a dose-response relationship between the amount of moldy or water-damaged surface and the probability of health risk was conducted mostly in *residences* rather than in commercial buildings. For example, the number of hours, days, weeks and years that an occupant is exposed to dampness in a home, apartment or bedroom is far larger than the amount of time occupants spend in hotels or airports, unless they are employees. When other factors are equal, dampness increases the probability of occurrence of respiratory health problems from spaces where people spend more time, as shown by research in both homes and offices (Park et al. 2004, Mendell and Kumagai 2016).

Individual occupant sensitivity

Clearly, hospital patients taking drugs that suppress their immune systems are more sensitive to any health risk, including effects of building dampness. Similarly, infants, children and the elderly have fewer defenses against environmental insults that most healthy adults may endure without obvious harm. Also, individuals who have allergic sensitivities are less able to endure an environment that others of similar age and health status might find less risky, as shown in Figure 2. So, all other factors being equal, it is reasonable to assume that individual sensitivity is an important factor in determining health risk, and to date, this sensitivity has been difficult to quantify for specific individuals.

The recommended dampness description is based on the precautionary principle

Based on the history of indoor air and mold investigations in North America and Northern Europe over the last 25 years, it is clear that not all occupants share the same probability for health risk in damp spaces. Further, some may elect to occupy spaces that elevate the probability for negative health effects if they so choose. Adults are entitled to accept risk, absent any coercion of organizational or economic necessity, and assuming the individual is capable of informed consent, and has been informed, and has in fact consented to the risk.

But given ASHRAE's stated mission; "to advance the arts and sciences of heating, ventilation, air conditioning and refrigeration *to serve humanity* and promote a sustainable world" we believe that the Society should inform the public of factors that we know increase the probability of negative health effects, rather than waiting until we know the exact percentage of occupants that face that risk at each level of personal sensitivity, or waiting until we know the exact number of hours of exposure that represent an increase in risks in each type of building.

We recommend the description of health-relevant indoor dampness stated above, based on the precautionary principle that obvious risk factors should be eliminated when they are known, even if all the mechanisms that lead to risk are not fully understood.

QUANTITATIVE TESTS WITH EARLY WARNING THRESHOLDS

Delaying action until indoor spaces become damp within our recommended description is not in the public interest. Accordingly, building owners and operators need quantitative tools and tests that help them recognize the approach of future problems, so they can prevent health-relevant dampness ***before*** it occurs.

But before considering the use of any quantitative tests and thresholds, the reader should keep in mind some important cautions about building dampness, beginning with its dynamic bio-hygro-thermal variation over time, and the critical importance of the exact location of any measurements.

The importance of measurements over time

The real-world constraint of limited budgets create a strong desire for simple, one-time, one-location measurements that conclusively warn or reassure managers and occupants about dampness risks. Unfortunately, risks from building dampness and microbial growth are micro-geographic and constantly-changing.

So any single snapshot measurement, taken at any one location is simply never going to be a conclusive indicator of the presence or absence of health-relevant dampness in the *entire* building. Moisture, mold and bacteria are always present in buildings. It is the *excessive accumulation of these over time in specific locations*, that causes problems.

Therefore the *change (or lack of change)* in exactly-located measurements over time provide the best indication of the presence or absence of excessive moisture accumulation that can lead to microbiological growth. When reliable indicators are needed, investigators and building owners are encouraged to make observations and keep records of measurements *over time*, and to make measurements that are recorded as being located within inches.[2]

These thresholds are not indications of elevated health risk

These recommended thresholds of concern have not been linked to current health risk from dampness. Neither owners nor occupants should treat these tests and threshold values as panic alarms.

These thresholds do not imply a standard of care

Furthermore, these thresholds are *not* intended to imply either contractual obligation, or a professional standard of care, or violation of manufacturer's warranty, or as a substitute for professional judgement in connection with construction defect disputes. These thresholds only serve as early warnings of

[2] Extensive discussion of the extreme temporal and spatial variation of surface water activity in building assemblies, and the strong effects on fungal growth facts that result from those variations can be found in ASHRAE 2008, ASHRAE 2009, Glass et al 2015, Ueno 2015, Adan 2011, Vereecken et al 2012, Li, Y. et al. 2012, Krus et al 2010, Viitanen 2007, Neilsen et al 2004, Sedlebauer 2001, Rowan et al 1999 and IEA Annex 14 1991.

"abnormal" conditions; those that are not in the normal range expected for most buildings that are well designed, built and operated. If such conditions are allowed to persist, excessive moisture could accumulate over time, which in turn could lead to microbial growth and health-relevant indoor dampness in the future.

Early warning thresholds of possible future problems

Always keeping in mind the many cautions above, our committee has reached consensus on four test measurements along with suggested threshold values that can serve as early warning signs of *future* health-relevant dampness. Each of these indicators is important in and of itself. But when more than one is present in the same space, the early warning to building owners and occupants becomes stronger.

1. **Persistent water activity (a_W) at the surface of organic materials or coatings or untreated paper-faced gypsum board in excess of 0.75.**

For most building professionals, the term water activity will be new and unfamiliar. Therefore a short explanation is needed, to clear up the confusion built up over the last 40 years about the relationship between relative humidity, moisture content and microbial growth risk.

In short, fungi and bacteria grow and multiply on surfaces. They may survive in air, but they grow to problematic levels only on surfaces. So surfaces, rather than air, must become the focus of any building manager's understanding of mold growth and its attendant health risks, when making decisions about building management and maintenance.

Further, mold and bacteria only grow on surfaces that retain sufficient moisture *over time*. But not all moisture is equally available to support growth. In some materials, moisture is tightly bound to the surface, and cannot be used by bacteria and fungus. In other materials, the moisture is easily accessed to support microbial growth. Microbiologists have found, after over 150 years of research, that the most reliable moisture-related metric that governs growth is the "water activity" at the surface of the material in question. Water activity could also be described as a measurement of the "bioavailability" of moisture in a material. It is in fact a measurement of the difference in water vapor pressure between the fungal or bacterial cell and the moisture in the surface on which it is located.

The 40-year confusion arises because of the way water activity is measured in laboratory settings where mold and bacterial growth has been studied and quantified. When the surface and the surrounding air are at perfect hygrothermal equilibrium (when the temperature and relative humidity of both are identical) then the water activity (the relative vapor pressure difference) can be quantified by measuring the relative humidity of the air inside the culture dish where all is at hygrothermal equilibrium. The biologist uses the decimal fraction of relative humidity to quantify water activity, ie: an equilibrium relative humidity of 85% is expressed as 0.85 water activity.

The confusion within the building community comes from the mistaken assumption that relative humidity in the air is the same as relative humidity at the surface. In fact, they are rarely the same, because of three factors: the difference between surface and air temperatures, the presence of sub-surface moisture, and the minute-by-minute changes in all of those variables inside complex building assemblies.

Outside of an environmental chamber that contains fungal growth sealed in a petri dish, nothing is ever at equilibrium. In buildings, moisture and heat is perpetually moving around within, as well as into and out of materials in small or large amounts, every minute. So the traditional use of RH in the air as a threshold of concern is both erroneous and misleading (ASHRAE 2008, ASHRAE 2009, ASHRAE 2015, EPA 2013). Instead, investigators and building managers should focus on the more reliable risk indicator of surface water activity.

Estimating the surface water activity can be done by measuring the equilibrium RH *of the surface* in one of two ways:

a. Attach an RH sensor to the surface in question, inside an air-tight cover sealed to that surface. After enough time has been allowed to achieve near equilibrium of BOTH temperature and humidity for all components (the surface under the cover, the sensor itself and the air inside the sensor cover), an RH measurement, converted to its decimal equivalent, is a measurement that approximates water activity and therefore helps assess microbial growth risk.

b. A second means of approximating surface water activity is to measure the dew point of air as close to a surface as is practical, using a handheld thermohygrometer. Then use an infrared surface thermometer or a thermocouple to measure the surface temperature. Using a psychrometric chart or computer app, plot or enter the *surface* temperature plus the *air's* dew point to arrive at a relative humidity value. The decimal equivalent of that surface RH is an approximation of its current water activity. Values above 0.75 indicate that water activity is above normal indoor levels, at least at that specific location, at that specific moment in time, on that specific surface

Documents and logic that support the suggested threshold of concern: ASHRAE Standard 160 recommends that in the absence of more specifically-known parameters for risk of mold growth, those who model the hygrothermal behavior of building systems should be aware that risks of mold are higher when the equilibrium relative humidity (the water activity) at the surface of organic materials and coatings stays above 80% for a moving average of 30 days. That criterion is based on several long-term research efforts that are specific to real-world building systems and building materials in situ, as opposed to only laboratory studies in sealed chambers at perfect and static equilibrium with growth media engineered to be ideal for fungus and bacteria. Many comparisons between laboratory conditions and field conditions have been performed over the last 30 years in Northern Europe and North America, including: Glass et al 2015, Ueno 2015, Adan 2011, Vereecken et al 2012, Krus et al 2010, Viitanen 2007, Neilsen et al 2004, Sedlebauer 2001, Rowan et al 1999, IEA Annex 14 1991).

These referenced comparisons between models, lab results and field results consistently show two facts. First, for exterior walls and the very long wetting-drying cycles endured by wood framing, plywood or oriented strand board inside exterior walls, the 30-day average 80% ERH upper limit is conservative, ie: mold is very unlikely to grow, even if that limit is not maintained, and even when condensation occurs intermittently. However, these same comparison studies also show that for paper-based products indoors, such as the paper and cardboard faces of interior gypsum board, an ERH of 75% is still risky with respect to mold growth, if accompanied by intermittently higher ERH or condensation, even if the time of wettedness (time above and ERH of 75%) is less than a few hours.

Therefore, the logic for a setting a lower threshold level than 80% surface ERH [0.80 a_W] is the same as for any "safety factor" used when the goal is to reduce risk in systems that have many unknowns. In short, the research shows conclusively that above 0.8 surface water activity (80% equilibrium relative humidity) there is a risk of mold growth within 30 days.Therefore we recommend using a threshold of concern known to be *above normal* levels, but also *below the level of known risk*: namely a water activity of 0.75.

2. Persistent moisture content above 15% wood moisture equivalent (WME) in organic materials or coatings or untreated paper-faced gypsum board, as measured with a resistance (pin) moisture meter.

High moisture content measurements in building assemblies frequently (but not always) correlate well with characteristics that describe a building or space that exhibits health-relevant dampness. (Macher et al. 2015) Furthermore, wood-based moisture meters are easily available, inexpensive, easy to use and in general are also reliable *enough*, and accurate *enough* to identify locations with excessive moisture accumulation.

The caution that a resistance-type or "pin meter" should be used to make decisions about moisture content reflects the fact that measurements made with capacitance ("non-penetrating") meters are less consistent than resistance measurements. Such non-penetrating meters are very useful for quickly locating areas of concern, without the need to puncture a surface. However, meters that measure capacitance, or impedance or radio frequency read out on many different scales, all of which are incompatible with each other and most of which are "relative" values rather than being equivalent to percent of dry wood moisture content (WME). So after fast scans with non-penetrating meters help the investigator locate areas of concern, a pin-type meter will ultimately be more reliable for making decisions about whether a specific location has a moisture content that is within a normal range, or is abnormally high.

Documents and logic that support the suggested threshold of concern: When building materials made of soft wood fibers (such as oriented strand board, paper, cardboard and cellulosic ceiling tile) come to equilibrium with air at 75% RH, their moisture content is approximately 14-15% of their dry weight. The exact relationship between WME and ERH varies with the product, its fiber type, manufacturing processes, mechanical and sorption-desorption characteristics, adhesives, coatings and possible conductive additives. But the general relationship is similar to intact soft wood lumber, as shown in Figure 3 below (USDA 2010, Chapter 4, Glass and Zelinka). Given that the biological availability of water in materials increases to levels of concern above 0.75 water activity, 15% moisture content is appropriate for use as the threshold of concern for moisture content of organic materials, when measured by a moisture meter that is calibrated for wood.

Temperature		Moisture content (%) at various relative humidity values																		
(°C	(°F))	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
−1.1	(30)	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.4	13.5	14.9	16.5	18.5	21.0	24.3
4.4	(40)	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.3	13.5	14.9	16.5	18.5	21.0	24.3
10.0	(50)	1.4	2.6	3.6	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.2	12.3	13.4	14.8	16.4	18.4	20.9	24.3
15.6	(60)	1.3	2.5	3.6	4.6	5.4	6.2	7.0	7.8	8.6	9.4	10.2	11.1	12.1	13.3	14.6	16.2	18.2	20.7	24.1
21.1	(70)	1.3	2.5	3.5	4.5	5.4	6.2	6.9	7.7	8.5	9.2	10.1	11.0	12.0	13.1	14.4	16.0	17.9	20.5	23.9
26.7	(80)	1.3	2.4	3.5	4.4	5.3	6.1	6.8	7.6	8.3	9.1	9.9	10.8	11.7	12.9	14.2	15.7	17.7	20.2	23.6
32.2	(90)	1.2	2.3	3.4	4.3	5.1	5.9	6.7	7.4	8.1	8.9	9.7	10.5	11.5	12.6	13.9	15.4	17.3	19.8	23.3
37.8	(100)	1.2	2.3	3.3	4.2	5.0	5.8	6.5	7.2	7.9	8.7	9.5	10.3	11.2	12.3	13.6	15.1	17.0	19.5	22.9
43.3	(110)	1.1	2.2	3.2	4.0	4.9	5.6	6.3	7.0	7.7	8.4	9.2	10.0	11.0	12.0	13.2	14.7	16.6	19.1	22.4
48.9	(120)	1.1	2.1	3.0	3.9	4.7	5.4	6.1	6.8	7.5	8.2	8.9	9.7	10.6	11.7	12.9	14.4	16.2	18.6	22.0
54.4	(130)	1.0	2.0	2.9	3.7	4.5	5.2	5.9	6.6	7.2	7.9	8.7	9.4	10.3	11.3	12.5	14.0	15.8	18.2	21.5
60.0	(140)	0.9	1.9	2.8	3.6	4.3	5.0	5.7	6.3	7.0	7.7	8.4	9.1	10.0	11.0	12.1	13.6	15.3	17.7	21.0
65.6	(150)	0.9	1.8	2.6	3.4	4.1	4.8	5.5	6.1	6.7	7.4	8.1	8.8	9.7	10.6	11.8	13.1	14.9	17.2	20.4
71.1	(160)	0.8	1.6	2.4	3.2	3.9	4.6	5.2	5.8	6.4	7.1	7.8	8.5	9.3	10.3	11.4	12.7	14.4	16.7	19.9
76.7	(170)	0.7	1.5	2.3	3.0	3.7	4.3	4.9	5.6	6.2	6.8	7.4	8.2	9.0	9.9	11.0	12.3	14.0	16.2	19.3
82.2	(180)	0.7	1.4	2.1	2.8	3.5	4.1	4.7	5.3	5.9	6.5	7.1	7.8	8.6	9.5	10.5	11.8	13.5	15.7	18.7
87.8	(190)	0.6	1.3	1.9	2.6	3.2	3.8	4.4	5.0	5.5	6.1	6.8	7.5	8.2	9.1	10.1	11.4	13.0	15.1	18.1
93.3	(200)	0.5	1.1	1.7	2.4	3.0	3.5	4.1	4.6	5.2	5.8	6.4	7.1	7.8	8.7	9.7	10.9	12.5	14.6	17.5
98.9	(210)	0.5	1.0	1.6	2.1	2.7	3.2	3.8	4.3	4.9	5.4	6.0	6.7	7.4	8.3	9.2	10.4	12.0	14.0	16.9
104.4	(220)	0.4	0.9	1.4	1.9	2.4	2.9	3.4	3.9	4.5	5.0	5.6	6.3	7.0	7.8	8.8	9.9			
110.0	(230)	0.3	0.8	1.2	1.6	2.1	2.6	3.1	3.6	4.2	4.7	5.3	6.0	6.7						
115.6	(240)	0.3	0.6	0.9	1.3	1.7	2.1	2.6	3.1	3.5	4.1	4.6								
121.1	(250)	0.2	0.4	0.7	1.0	1.3	1.7	2.1	2.5	2.9										
126.7	(260)	0.2	0.3	0.5	0.7	0.9	1.1	1.4												
132.2	(270)	0.1	0.1	0.2	0.3	0.4	0.4													

Figure 3. Wood moisture content (Douglas fir, measured gravimetrically) when at static hygrothermal equilibrium with the stated air temperature and relative humidity (USDA 2010 - Wood Handbook, Chapter 4, Figure 4-2 ,Glass and Zelinka)

Further support for the 15% WME threshold of concern as being “well above normal” comes from the fact that recommended installation moisture content for interior wood trim, cabinetry, wood trim and wood floors is recommended to match an annual average of interior wood moisture content of 9% in dry climates and 11% in humid coastal areas, with recommended maxima for any individual board of 10% and 13% respectively (USDA 2010, Chapter 13, Bergman). Therefore 15% would be abnormally high for interior woodwork in any climate.

Gypsum board is a material of much greater concern, because it is present in buildings in far larger amounts than wood products, and it’s paper face and cardboard backing are much more easily digestible by fungi than are intact wooden surfaces. The moisture content of gypsum board leaving the factory is below 1% of its dry weight, and the initial moisture content of cellulosic acoustic tile is below 6% of dry weight. In both cases, at those levels of actual moisture content, meters calibrated for wood (WME scale) are not likely to be able to read any moisture at all.

But both these materials absorb moisture in transit, and again during installation and normal building operation, eventually reaching moisture content levels that allow reading with a wood-based meter. Even in humid climates, normal WME readings for gypsum board and acoustic ceiling tile are rarely above 12% WME. Therefore as with other wood-based products, if the moisture content of interior gypsum board or acoustic tile is above 15% WME, it’s an indication that at least the surface of the material has come to equilibrium with a very high RH (above 75%). Therefore, something about the building’s design, construction or operation is definitely above normal levels. So a WME reading at or above 15% can be recognized as a warning of future problems, if that moisture level persists over time.

3. Persistent moisture content above 80% equilibrium RH in concrete or masonry that is either coated with—or is in contact with—organic materials, adhesives or coatings.

Damp concrete and masonry block are frequently sources of excess moisture inside newly-constructed buildings. While the material itself resists microbiological growth, it is rarely uncoated, and is often in direct contact with moisture-sensitive materials such as gypsum wall board, carpet and tile adhesives and paint. Excessive moisture in the concrete (and masonry) will migrate to organic material, perhaps raising its surface water activity to levels that support microbial growth. Consequently, avoiding microbial growth requires that concrete and masonry be dry enough to limit moisture transfer to nearby materials and coatings.

Each manufacturer of coatings and adhesives has different recommendations (or indeed warrantee requirements) for dryness of concrete and masonry to avoid excessive moisture transfer that could damage the product or interfere with adhesion, coating cure or service life. Manufacturers of gypsum board are less specific. But it seems prudent to assume that if concrete is too wet to accept a coating or an adhesive, it is also too wet to be in contact with untreated paper-faced gypsum board.

Our task group notes that, given the widespread use of paper-faced gypsum board in all parts of the world, plus the fact that it is often in contact with concrete and masonry, published research concerning acceptable and inspectable levels of moisture in concrete and masonry is missing from the literature, and would be useful to the public and to building professionals.

Three methods are commonly used to assess the moisture levels of concrete and masonry. Each of these methods is effective for specific purposes, and each method uses a different system of units to define the condition of concrete that is “dry enough” to avoid significant risk:

a. Equilibrium RH test: Threshold of concern: 80% ERH or above

This test has become the preferred choice for coating and flooring manufacturers. The fact that it is not limited to horizontal surfaces provides a strong advantage over the MVER test (c., below). Also, this test is a certain measure of moisture content, where the MVER test is instead a test that measures emission rate, rather than moisture content. But the fact that this test requires both 72 hours and drilling holes in the substrate often rules it out for use on floors and walls that cannot—or should not—be drilled.

Advantages: Conclusive measurements of moisture content, supported by robust manufacturer infrastructure and procedures defined by ASTM Standard F2170-11 (Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In Situ Probes). The test can be used for any thickness of concrete or masonry at any vertical, inclined or horizontal orientation.

Limitations: Requires drilling holes in the concrete or masonry (Three holes for the first 1,000 ft2 [100 m2] of concrete surface, thereafter one hole per additional 1,000 ft2 [100 m2].), and requires a full 72 hrs at the service temperature to reach relevant hygrothermal equilibrium. Cost of sensors is significant, and each has limited life. Measurements that are fully-compliant with ASTM Std F2170-11 also require sensors to be calibrated before each test. Further, if vapor barrier coatings such as “curing coatings” are applied to the concrete or masonry, the fact that moisture content is elevated may present no risk to nearby organic materials, adhesives or coatings.

Documents and logic that support the suggested threshold of concern: Each coating and flooring manufacturer has specified limits for moisture content of concrete before installation. Some require as low as 75% ERH, and others tolerate ERH of 85% or even 95% for specialized coatings designed to be vapor barriers. But our purpose in suggesting the limit of 80% is to provide a “normal” threshold of concern, and not one which is extreme, or bounded by the specific requirements of any single product or installation configuration.

In the absence of any universally-established North American limit, we note that an equilibrium RH reading of 80% or less, first established in building codes in both Finland and in Sweden, has become a defacto limit in much of the world. This limit is referenced by some manufacturers and by industry association publications to avoid excessive moisture transfer to adhesives and coatings on concrete and masonry (Kanare 2005).

b. Capacitance-based concrete moisture meter. Threshold of concern: 3% or above

Measurements taken with these instruments are most useful for a quick scan to locate areas of significant moisture differences, and as early warnings of extreme moisture. When greater certainty becomes important, the other methods described here are more useful than capacitance readings.

Advantages: Instant reading and low-cost, and accurate enough for prompting concern and action to dry the material before coating or applying adhesives, and before attaching vulnerable materials.

Limitations: Readings are neither accurate nor consistent between concrete mixtures, and readings vary widely based on differences in the operators’ hand pressure. A single manufacturer makes the most widely-used instrument, and the other two manufacturers use different and widely-varying scales for moisture content. Readings for the same moisture content differ widely between meters from different manufacturers and also vary between different models from the same manufacturer.

Documents and logic that support the suggested threshold of concern: The suggested 3% upper limit, as read from one specific instrument; the Tramex “Concrete Moisture Encounter”, is based on an informal survey of water damage and construction drying experts who regularly use all three methods of measuring moisture content of concrete and masonry to establish when damp materials have been “sufficiently dried” to allow installation of finishes and flooring.

As reported by Lee (2016), the 3% reading on a Tramex concrete meter is by no means a signal that the concrete is dry enough to allow installation. It serves instead as a useful warning signal that in one specific location, the material is ***far*** too wet to allow installation of moisture sensitive coatings, directly-attached gypsum board or water-based adhesives.

c. Moisture vapor emission rate (MVER). Threshold of concern: 3 lb/1000 ft^2/24h or above

This is a well-known test that is often the basis of warrantees for flooring, adhesives and coatings. In the past, when these issues are in question, this test (or the ERH test) has been relied upon to provide the most credible results. This test is supported by robust manufacturer and service company infrastructure and by procedures defined by ASTM Standard 1869-11 (Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride).

Advantages: A direct measurement of the rate of water vapor migration out of concrete, which is the most relevant factor for assessing the relative risk of mold growth in nearby materials or coatings. It is relatively low in cost. It is a simple procedure that has been used for decades to ensure the level of moisture is safe for installation of flooring adhesives and finish flooring. Finally, it does not require drilling holes or chipping out test samples from the concrete surface.

Limitations: Requires three test kits for the first 1,000 ft^2 [100 m^2] of surface plus one test kit for every additional 1,000 ft^2 [100 m^2]. Kits are not reusable. Requires a full 72 hours at service temperature for reliable results. As a practical matter, the test can only be performed on horizontal surfaces. Results, while generally consistent, are subject to technicians' errors in installation or in the before-after weight measurements, and in the arithmetic calculations that follow these time-weight change measurements.

Documents and logic that support the suggested threshold of concern: Each coating, adhesive and flooring manufacturer sets limits for moisture content of concrete or masonry. But in the absence of more specific limits, we can look to their industry association, and a recent survey of manufacturer's specified limits for a useful default high limit.

The suggested threshold of concern of 3lb/1,000 ft^2/24 hrs comes from the Resilient Floor Covering Institute (1995) as referenced in Engineering Bulletin 119 (Kanare - 2005) published by the Portland Cement Association. These publications, often referenced in specifications within the flooring industry, suggest that at emission rates at 3lb/1,000 ft^2/24 or below, most tile adhesives and most flooring materials will tolerate moisture absorption without damage.

Further support for using 3 lb as a default limit for water vapor emission rate comes from a recent survey of the specified limits from more than twenty manufacturers of flooring and flooring adhesives (IFTI 2014). As of 2014, all of the manufacturers contacted specified that limit as the maximum allowable moisture in concrete prior to installation of their products.

4. Persistent indoor air humidity above a dew point temperature of 60°F (15°C) in buildings that are mechanically cooled... or above a dew point temperature of 45°F (7°C) in buildings that are being heated.

Buildings cooled by natural ventilation alone have very low HVAC-dependent risk of microbial growth. In contrast, mechanical cooling creates higher risks, because it creates cold surfaces. Cold surfaces increase risk of persistent dampness, because they encourage absorption of moisture from air, while at the same time impeding the release of that moisture back into the air. Further, the greater the mass of water vapor in the air, the greater the risk of absorption and persistent dampness when surfaces become cool. The indoor air dew point is a reliable measurement of the mass of water vapor available for absorption, and therefore potentially available to support microbial growth.

Consequently, designers, builders and operators need to be aware that although cooling systems do remove moisture from air, they also create a significant risk of excessive indoor moisture and and inside the cooling system itself.

Distinguishing between "normal" and "abnormally high" indoor dew points in mechanically-cooled buildings
Typical HVAC design practice sets a target indoor condition at or near a temperature of 75°F [24°C] and a relative humidity of 50%. That means that most designers' intended indoor dew point is at or near 55°F. While it may often be the case that cooling systems fail to maintain that dew point as a firm upper limit, it is rarely the case that an owner or designer *intends* the indoor RH to be *above* 60% as the basis of design. Said another way, if the dew point temperature inside the building is above 60°F, it is an indication that something about the design, construction or operation of the cooling system is "not normal" and can therefore serve as a warning of excessive indoor moisture and possible future microbial growth.

Using dew point temperature rather than RH as the primary dampness risk indicator.
Using a 60°F dew point as the threshold of concern is much more reliable than using 60% RH as a risk indicator. Condensation is the principal risk, followed by the risk of moisture absorption during unoccupied hours. RH measured at the thermostat does not alert the building manager to these risks.

Monitoring the dew point provides a more reliable risk indicator than monitoring the RH. Both air and surface temperatures throughout the complex spaces of any building vary widely above and below the thermostat set point temperature. So using relative humidity in the air as a metric of concern is highly misleading. Focusing on an RH limit leads to needless concern when the temperature of air is cool, as in the case of supply air temperature during cooling operation. An RH focus also allows an unwarranted sense of safety when the air temperature is above normal; such as in a school during summer vacation, when the indoor temperature may be quite high.

Documents and logic that support a 60°F dew point temperature as a threshold of concern
A more detailed discussion of the logic for setting either 55°F or 60°F dew point as a prudent limit for “normal” indoor humidity (and as a reasonable compromise with respect to energy use to maintain building dryness) can be found in the ASHRAE Humidity Control Design Guide, the ASHRAE Guide for Buildings in Hot & Humid Climates, and in Chapter 62 of the 2015 ASHRAE Handbook—Applications and in the Moisture Control Guidelines published by the U.S. EPA. (ASHRAE 2001, ASHRAE 2009, ASHRAE 2015 and EPA 2015)

Beyond the issues of building dampness and microbial growth, there is the matter of thermal comfort for occupants. ASHRAE Standard 55 (Thermal Environmental Conditions for Human Occupancy) warns that holding other factors equal, it will be useful to hold the dew point temperature below 62°F if the goal is to satisfy 80% of occupants. The “center” of the summertime humidity comfort range (that which is likely to satisfy more than 80% of occupants) is a dew point of 45°F. So for most HVAC designs, while excursions above a 60°F dew point in a mechanically-cooled building may happen, these are neither normal nor are they intended to be normal by either owners or HVAC designers. And a high dew point represents a direct measurement of the degree of risk of moisture absorption or condensation on cool surfaces. So a ***persistent*** dew point above 60°F is a useful indicator that there is an elevated risk of future microbial growth in hidden spaces, in buildings that are mechanically cooled.

Heated buildings in cold weather - Documents and logic that support a 45°F dew point temperature as a threshold of concern In heated buildings during cold weather. An indoor air dew point of 45°F [7°C] is probably a prudent upper limit for existing, conventionally constructed buildings in warm or mixed climates (International climate zones 1 through 5 as referenced in ASHRAE Standard 90.1-2013, Table B1-4, page 184).

That said, it must be admitted the truly prudent upper limit for indoor dew point depends on many, many factors that are difficult to predict. At present, there is no authority that backs up the 45°F dew point as a threshold of concern beyond the anecdotal experience of a limited number of building science professionals, all of whom are uncomfortable with the idea of a single threshold of concern to cover all types of buildings, especially those in cold climates (International climate zones 6 through 8).

The goal of limiting the indoor dew point in winter is to limit the condensation that takes place inside walls to the amount of moisture that the building can tolerate without growing mold. In cold weather, the building’s moisture tolerance depends on the exact configuration of all layers, gaps, cracks and holes in its enclosure (which often differs substantially from its designers’ intentions) as well as on the wind pressure, outdoor temperature and indoor temperature.

So the selection of a single number as a prudent upper limit for dew point in winter is, to say the least, optimistic. The upper dew point limit will be specific to each building enclosure and each set of indoor-outdoor temperature differences. But in the absence of more certain knowledge of all the gaps, cracks and holes, and on knowledge of the number and location of thermal bridges that may or may not exist, or of the exact amount of cold air infiltration the building may endure... a 45°F [7.2°C] dew point seems a plausible prudent upper limit during all but very cold (and extended) outdoor temperatures.

For buildings that are very air-tight and exceptionally well-insulated including window frames and glazing, a higher indoor dew point may be tolerable. But a lower indoor dew point will be safer for buildings in cold climates and those in any climate that may not have the benefit of an air-tight air barrier on the inside surfaces, to prevent exfiltration of high dew point indoor air outward through the cold exterior walls and roof.

REFERENCES

Adan, O. (2011) Chapter 7 - “Water relations of fungi in indoor environments.” , Fundamentals of mold growth in indoor environments and strategies for healthy living, Olaf C.G. Adan and Robert A. Samson (Eds.) Wageningen Academic Publishers.

ASHRAE (2008) Chapter 7 - “Mold and Mildew.“ Humidity Control Design Guide. ASHRAE Inc.

ASHRAE (2009) Chapter 5 “Avoiding Bugs, Mold and Rot” The ASHRAE Guide for Buildings in Hot & Humid Climates. ASHRAE Inc.

ASHRAE (2009) Chapter 17 “Avoiding Mold by Keeping New Construction Dry” The ASHRAE Guide for Buildings in Hot & Humid Climates. ASHRAE Inc.

ASHRAE (2015) “Chapter 62 - Moisture Management in Buildings.” ASHRAE Handbook—Applications. ASHRAE Inc.

Flannigan,B., and Miller, J.D. (2001) Chapter 21. “Microbial Growth in Indoor Environments” Microorganisms in Home and Indoor Work Environments: Diversity, Health Impacts, Investigation and Control Brian Flannigan, Robert Sampson and J. David Miller, Editors. Taylor & Francis 2001.ISBN 0-415-26800-1

Glass, S. Schumacker, C, Ueno, K. (2015) “The Long and Winding Road: The Remediation of ASHRAE Standard 160”. Proceedings of the 19th Westford Symposium on Building Science, August 2015. Published by Building Science Corp. Westford, MA

IFTI (2014) “A Guide to Flooring Moisture Problems”. Independent Floor Testing and Inspection, Concord, CA. (http://ifti.com/guide-flooring-moisture-problems)

Institute of Medicine (2004). Damp Indoor Spaces and Health. Washington, D.C., National Academies Press.

Iossifova, Y.Y, Reponen, T., Bernstein, D.I, et al (2007) “House Dust (1-3) Beta-D-Glucan and Wheezing in Infants” Allergy. 2007 May; 62(5) 504-513.

Iossifova, Y.Y, Reponen, T., Ryan, P., et al (2009) “Mold exposure during infancy as a predictor of potential asthma development” Annnals of Allergy, Asthma and Immunology, February 2009 Volume 102, Issue 2, Pages 131–137.

Jaakkola, M. S., R. Quansah, T. T. Hugg, S. A. Heikkinen and J. J. Jaakkola (2013). "Association of indoor dampness and molds with rhinitis risk: a systematic review and meta-analysis." J Allergy Clin Immunol **132**(5): 1099-1110 e1018.

Kanare, H.M. (2005). Concrete Floors and Moisture. Engineering Bulletin 119. Portland Cement Association. Skokie, IL.

Kanchongkittiphon, W., M. J. Mendell, J. M. Gaffin, G. Wang and W. Phipatanakul (2015). "Indoor environmental exposures and exacerbation of asthma: an update to the 2000 review by the Institute of Medicine." Environmental Health Perspectives **123**(1): 6.

Kennedy, K., and Grimes, C. (2013) “Indoor Water and Dampness and the Health Effects on Children” Curr Allergy Asthma Rep (2013) 13:672–680 Published online 19 Nov. 2013.

Krus, M, Seidler, M., Sedlbauer, K. (2010) “Comparative evaluation of the preditions of two established mold growth models” Proceedings of the Buildings XI Conference. ASHRAE, Inc.

Lee, Mickey (2016) Personal communication. As of 2016, Mickey Lee has 35 years of experience as the technical supervisor, research manager and chief instructor for a major worldwide water damage and construction drying company (Munters Moisture Control, later acquired by Polygon Group). From 2010-2016 he also served as the Committee Chair to revise the IICRC’s Standard S-500

(Water damage restoration), and he also both funded and guided research in concrete drying measurements in both Europe and the US. Many of these tests contributed to the foundation for Engineering Bulletin 119, written by Howard Kanare and published by the by the Portland Cement Association as noted above.

Li, Y. and Wadso, L. (2012) “Fungal activities of indoor moulds on wood as a function of relative humidiies during desorption and adsorption processes.” Engineering in the Life Sciences DOI: 10.1002/elsc.201200100 www.els-journal.com

Macher, J., Mendell, M. et al (2015) “Higher measured moisture in California homes with qualitative evidence of dampness” Indoor Air. John Wiley & Sons. www.wileyonlinelibrary.com/journal/ina

Macher, J., Chen., W., Mendell, M., Kumagai, K. (2014) “Comparison of Moisture Meters and a Water Activity Sensor to Determine the Dampness of Gypsum Wallboard” Indoor Dampness and Mold as Indicators of Respiratory Health Risks, Part 5. Indoor Air 2014, Hong Kong, ASHRAE, Inc.

Mendell, M. J., A. G. Mirer, K. Cheung, M. Tong and J. Douwes (2011). "Respiratory and allergic health effects of dampness, mold, and dampness-related agents: a review of the epidemiologic evidence." Environ Health Perspect **119**(6): 748-756.

Mendell, M. J. and Kumagai, K. (2016). “A review of observation-based metrics for residential dampness and mold: practical metrics showing dose-related associations with health.” Proceedings of the Indoor Air 2016 Conference, July 3-8, Ghent, Belgium.

Miller, J.D. (2011) Chapter 7 - “Health Effects from Mold and Dampness in Western Societies: Early Epidemiology Studies and Barriers to Further Progress” , Fundamentals of mold growth in indoor environments and strategies for healthy living, Olaf C.G. Adan and Robert A. Samson (Eds.) Wageningen Academic Publishers.

Miller, J.D., McMullin, D.R. (2014) “Fungal secondary metabolites as harmful indoor air contaminants” Applied Microbiological Biotechnology DOI 10.1007/s00253-014-6178-5 Published online 04 Nov, 2014. Springer Verlag, Berlin.

MFMA (2007) Guide Specifications for Maple Flooring Systems. Maple Flooring Manufacturer’s Association. Northbrook, IL www.mfma.org

Nielsen, KF, Holm, G, Uttrup, LP & Nielsen, PA 2004, 'Mould growth on building materials under low water activities: Influence of humidity and temperature on fungal growth and secondary metabolism' International Biodeterioration and Biodegradation, vol 54, pp. 325-336.

Ojanen, T., Lahdesmaki, K, Viitanen, H. et al, (2010). “Mold Growth Modeling of Building Structure Using Sensitivity Classes of Materials” ASHRAE Transactions - Buildings XI Conference Proceedings (2010) ASHRAE Inc.

Quansah, R., M. S. Jaakkola, T. T. Hugg, S. A. M. Heikkinen and J. J. K. Jaakkola (2012). "Residential dampness and molds and the risk of developing asthma: a systematic review and meta-analysis." PloS one **7**(11): e47526.

Rowan, N.J, (1999) “Prediction of toxigenic fungal growth in buildings by using a novel modelling system.” Applied and Environmental Microbiology, Nov 1999, p.4814-4821 Vol. 65 no. 11. American Society for Microbilology. (www.asm.org)

Sedlbauer, K. (2001) Prediction of mould fungus formation on the surface of and inside building components. PhD dissertation, Department of Building Physics, University of Stuttgart, Stuttgart, Germany.

Ueno, K. (2015) “Monitoring of Double-Stud Wall Moisture Conditions in the Northeast”. Building America Report 1501. U.S. Department of Energy. Published by Building Science Corp. Westford, MA.

US Environmental Protection Agency (2013) Moisture Control Guidance for Building Design, Construction and Maintenance. US EPA 402-F-13053: www.usepa.gov.iaq/moisture (Print edition published by ASHRAE Inc. 2016)

USDA (2010). Chapter 4 (Glass & Zelinka) - "Moisture Relations and Physical Properties of Wood", Chapter 13 (Bergman) - "Drying and Control of Moisture Content and Dimensional Changes", Wood Handbook; Wood as an Engineering Material (Centennial Edition). USDA Forest Products Laboratory, Madison, WI. http://www.fpl.fs.fed.us/documnts/fplgtr/fpl_gtr190.pdf

Vereecken, E., Roels, S., "Review of Mould Predition Models and their Influence on Mould Risk Evaluation." Building and Environment vol 51, (2012) p. 296-310. Elsevier Pblishing, www.elsevier.com

Viitanen, H., and Salonvaara, M. (2001). Chapter 4 "Failure Criteria." Moisture Analysis and Condensation Control in Building Envelopes. Heinz Trechsel, ED. ASTM Manual 40. 2001. www.ASTM.org

Viitanen, H., L Ojanen, T. (2007). "Improved Model to Predict Mold Growth in Building Materials." ASHRAE Transactions - Buildings X Conference Proceedings (2007) ASHRAE Inc.

Ojanen, T., Lahdesmaki, K, Viitanen, H. et al, (2010). "Mold Growth Modeling of Building Structure Using Sensitivity Classes of Materials" ASHRAE Transactions - Buildings XI Conference Proceedings (2010) ASHRAE Inc.

WHO (2009) Guidelines for Indoor Air Quality: Dampness and Mould. World Health Organization (WHO) Bonn, Germany: http://www.euro.who.int/__data/assets/pdf_file/0017/43325/E92645.pdf

COMMITTEE MEMBERS

Chair
Lew Harriman, FASHRAE - Director of Research & Consulting
Mason-Grant
Portsmouth, NH

1. **Representing the perspective of the ASHRAE Environmental Heath Committee**
Mark J. Mendell, PhD, Epidemiologist
Indoor Air Quality Section / EHLB / DEODC
California Department of Public Health
Richmond, California

2. **Representing the perspective of ASHRAE TC 9.6 - Healthcare Facilities**
Rick Peters, PE - President
TBS Engineering
Bainbridge Island, Washington

3. **Representing the perspective of ASHRAE TC 1.12 - Moisture Management in Buildings**
George DuBose, P.E. - President
Liberty Building Diagnostics Group
Zellwood, Florida

4. **Representing the perspectives of occupants who have experienced building-related health effects**
Carl Grimes, IEP - President
Healthy Habitats LLC
Denver, Colorado

5. **Representing the perspectives of owners/operators who regularly assess moisture-related problems**
Rick Frey, P.E. - Senior Director | Engineering Support - Architecture & Construction
Hilton Worldwide
Memphis, TN

6. **Representing the perspective of public health officials and investigators**
(Nominated by the National Association of County and City Health Officials - NACCHO.org)
Robert Maglievaz, MSPH, RS CIH
Environmental Administrator
Florida Department of Health in Volusia County
Daytona Beach, FL 32117

Indoor Passive Panel Technologies for Air Cleaning in Buildings

What is the issue?

Currently, there are many building materials and coating products available in the market that claim to enhance Indoor Air Quality (IAQ) by removing indoor air contaminants. This technology, known as indoor passive panel technology (IPPT), consists of building materials or coatings intentionally designed to remove chemical or biological contaminants without requiring additional energy input beyond normal building operations. IPPT use has the potential to lower airborne pollutant levels at the same time indirectly increase energy saving while increasing energy savings through reducing outdoor air ventilation rates. IPPT manufacturers' claims include energy savings, continuous functionality (for example even after multiple layers of paint coats have been applied), little maintenance (e.g. self-sanitizing; self-cleaning) and improved building occupants' health and productivity.

What does it mean to ASHRAE?

There are several processes involved in the removal of indoor contaminants using IPPTs. These processes include sorptive based IPPTs and photocatalytic oxidation (PCO) based IPPTs. Sorptive based IPPTs rely on adsorption and chemisorptions processes while PCO based IPPTs rely on the use of photocatalysts coated on building materials that it irradiated with either ultraviolet or indoor light. Literature on performance of these technologies has documented potential issues associated with their use, which include:

- Re-emissions of captured gaseous contaminants;
- Low effectiveness of PCO based products' performance under real-life conditions (e.g. PCO based technology traditionally rely on UV light irradiance which is very low in indoor environments);
- Surface treatment (e.g. paint, prime, wallpaper) or particle soiling on IPPT surfaces may diminish? performance;
- Generation of harmful by-products (e.g. formaldehyde, ozone) for PCO based products.
- Impact of variations in environmental conditions or performance conditions

There is a lot of potential for impact considering that IPPT can be used in a broad range of building materials within the built environment. It is unclear if this impact can be positive or negative for IAQ and the occupants' health.

Currently, there are inadequate information to evaluate actual performance of IPPT in indoor environments. Available standards to assess the performance of the two types of IPPT technologies have focussed on evaluating removal performance of selected airborne organics using small specimens in small chambers and using UV light sources (not visible light sources). Of additional interest to the field of IAQ and ASHRAE, the marketing of IPPT as an "energy efficient solution" has not been validated by research. There is a potential that the adoption of IPPT as an energy efficient and sustainable approach may prevail over other IAQ solutions (ventilation and air cleaning) that may have positive energy consequences but unknown health impact.

What action item should be considered?

ASHRAE should develop a description of the various applications of IPPT in building materials and coatings, and evaluate their performance indoors. ASHRAE should inform the public about the true performance of various IPPT materials and provide guidance with regards to its safe use in the indoor environments.

ASHRAE should also review and initiate research in this area. For example:

1. A comparison of the effectiveness of IPPT in reducing contaminants of concern indoors compared to their conventional counterpart in air cleaning technologies (e.g. in-duct or portable air cleaners), and evaluate the impact on energy use in buildings in controlled chamber studies as well as field studies.
2. Determine the effectiveness of PCO based IPPT using typical indoor lighting sources (e.g. fluorescent, LED) and evaluate by-product formation (e.g. ozone, formaldehyde).

3. Compare the performance of IPPT in removing indoor contaminants in small chamber experiments with large chamber or in-situ performance in real buildings.
4. Evaluate the IPPT performance using test samples that replicate their use for real indoor environment applications (e.g. using samples that are painted or installed with wallpaper).
5. Evaluate the IPPT performance in different environmental conditions.

Unique Tracking Number Assigned by MORTS RTAR#

RESEARCH TOPIC ACCEPTANCE REQUEST (RTAR) FORM

TC/TG: TC 03.06

Title:

Potable hot water temperature – safe and sensible temperature levels that take into account issues with scalding, Legionella, and conservation.

Research Category:

Primary: Indoor Environmental Quality

Secondary: Energy and Resources

Research Classification:	TC/TG Priority:	TC/TG Vote:
Applied	2	Pending, email ballot in progress

Estimated Cost:

Other Interested TC/TGs:188, 3.6, 6.6, 90.1, Environmental Health, 9.06 Healthcare

Possible Co-funding Organizations:

Environmental Protection Agency, NSF, IAPMO, Healthcare or Hotel

Handbook Chapters to be Affected by Results of the Project:

Any sections having to do with Legionella, service water (building potable hot water), conservation, healthcare and water treatment.

State-of-the-Art

Presently the issue of recommended temperature ranges is based more on marketing literature than science. There is a strong need for unbiased review of scientific recommendations for safe temperature ranges. Over the years plumbing codes have been revised to include lower temperatures for energy conservation without recognizing the risk these temperatures have for Legionella.

Scald temperatures have been established based significantly on scald control product marketing papers with dramatic safety factors added to temperature limits that have greatly increased risk for Legionella. Healthcare temperature recommendations were created before the close link between temperature and waterborne pathogens such as Legionella was known and before science documented the significant amount of illnesses associated with waterborne pathogens.

Initial studies by Consumer Safety Products recommended lowering single family home hot water heaters from above 140°F to below 130°F. These studies did not apply to healthcare or commercial institutional buildings.

The RTAR will review unbiased research on safe levels for water temperatures in healthcare, long term care and other non-single family home buildings for the purpose of developing a published range of temperatures for codes and designers for water temperatures from cold to hottest ranges including items such as public handwashing, safety eye wash and safety showers, sink and shower temperatures in healthcare, long term care and commercial buildings, as well as any other ranges used in codes.

These ranges will develop sorely needed state of the art recommend temperatures for applications listed above using scientific fact to weigh risks associated with scald, Legionella and benefits for environmental and energy conservation.

Advancement to the State-of-the-Art:

Huge, really really huge.

Justification and Value to ASHRAE:

Presently there are many conflicting statements in codes regarding this issue in the US, Internationally and even within ASHRAE itself. ASHRAE 90.1, 90.2 189 and 191 offer recommendations that significantly conflict with recommended controls for Legionella.

ASHRAE 90.1 for examples states “7.4.4.3 Outlet Temperature Controls. Temperature controlling means shall be provided to limit the maximum temperature of water delivered from lavatory faucets in public facility restrooms to 110°F” this statement significantly conflicts with earlier more sensible statements in previous versions of 90.1 and greatly increases risk for Legionella.

Now that ASHRAE 188 has become an International Legionella standard offering best practices for Legionella control it is more important than ever that ASHRAE have one set of temperature recommendations that are consistent, based on science and not in any way representing false data proposed by manufacturers.

This project addresses multiple key research initiatives established by ASHRAE. The primary focus is Indoor Environmental Quality. This ranking is determined by the nature of the environmental quality hazard, as it often directly affects the health or even the mortality of the building occupants. Specifically it proposes to reduce the risk of Legionnaires Disease associated with building hot water systems and reduce the amount of disinfectant chemicals needed to achieve that end.

Energy and Resource Conservation may be considered a secondary benefit. The outcome of this research may likely result in revised best practice design methods that will reduce energy consumption, life cycle cost (by minimizing equipment corrosion), and environmental impact (by reduced chemical biocide demand), and that will allow system life span and IEQ to be maximized.

Results of this study may be incorporated into the Handbook as best practice design methods and will also be considered by GPC12, Standard 188,

Objective:

Review unbiased scientific literature on scalding and Legionella and produce a summary of temperature ranges useful for code developers as well as building operators and designers. These temperature ranges would include from coldest to hottest ranges based on scald data in hospitals, long term care facilities, and non-healthcare commercial institutional facilities. Develop data that can be used by all looking for standardized scientific information on safe hot water temperatures, water saving issues, Legionella control temperatures. The groups this would impact groups that produce standards, codes, guidelines or training for any issues related to water temperature control in building water system, water conservation in building water systems or Legionella control in building water systems. This would include the following;

- All ASHRAE committees, codes and papers dealing with any of these issues
- All Federal, State and Local Governmental organizations such as EPA, CDC, CMS, which produce standards or guidelines dealing with any of these issues.
- All healthcare organizations that provides guidelines or training on hospital construction and hospital safety including FGI, ASHE, APIC, and SHEA
- All technical groups that develop standards and guidelines for water conservation, energy conservation and / or Legionella control such as ASME, USGBC, …