WHEA Lunch and Learn

Humidity in Healthcare

Your Presenters

- Professional Engineer
- 35 years of healthcare Engineering
- Henneman Engineering Inc

- Professional Engineer
- 30 years of Healthcare Engineering
- ASHRAE TC 9.6 & Standard 170 Committee
- ASHE Conf. Panel co-presenter " Ask the Code Experts"
- Erdman Company

Agenda

- Humidity Basics
- Stakeholders and why humidity levels are important
- Codes, Guidelines, and Accreditation requirements
- History and Trends in Humidity standards
- Specialty areas within Healthcare
- Compliance Challenges
- Controllability Between Spaces
- Humidification Equipment

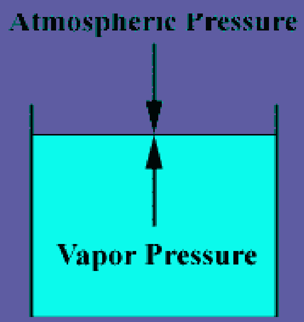
Basics

Relative Humidity

Ratio of Moisture in the air to the highest amount of moisture the air can hold at that temperature

Vapor Pressure

Pressure exerted by vapor in the air

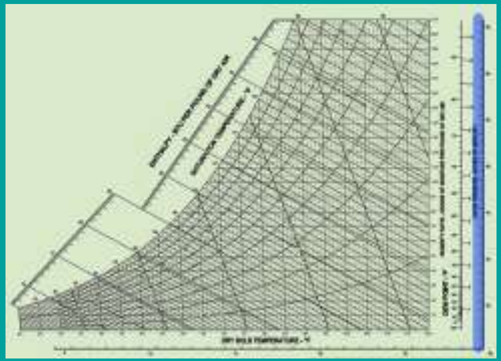


Dew Point

Temperature where the water vapor in air will condense to a liquid

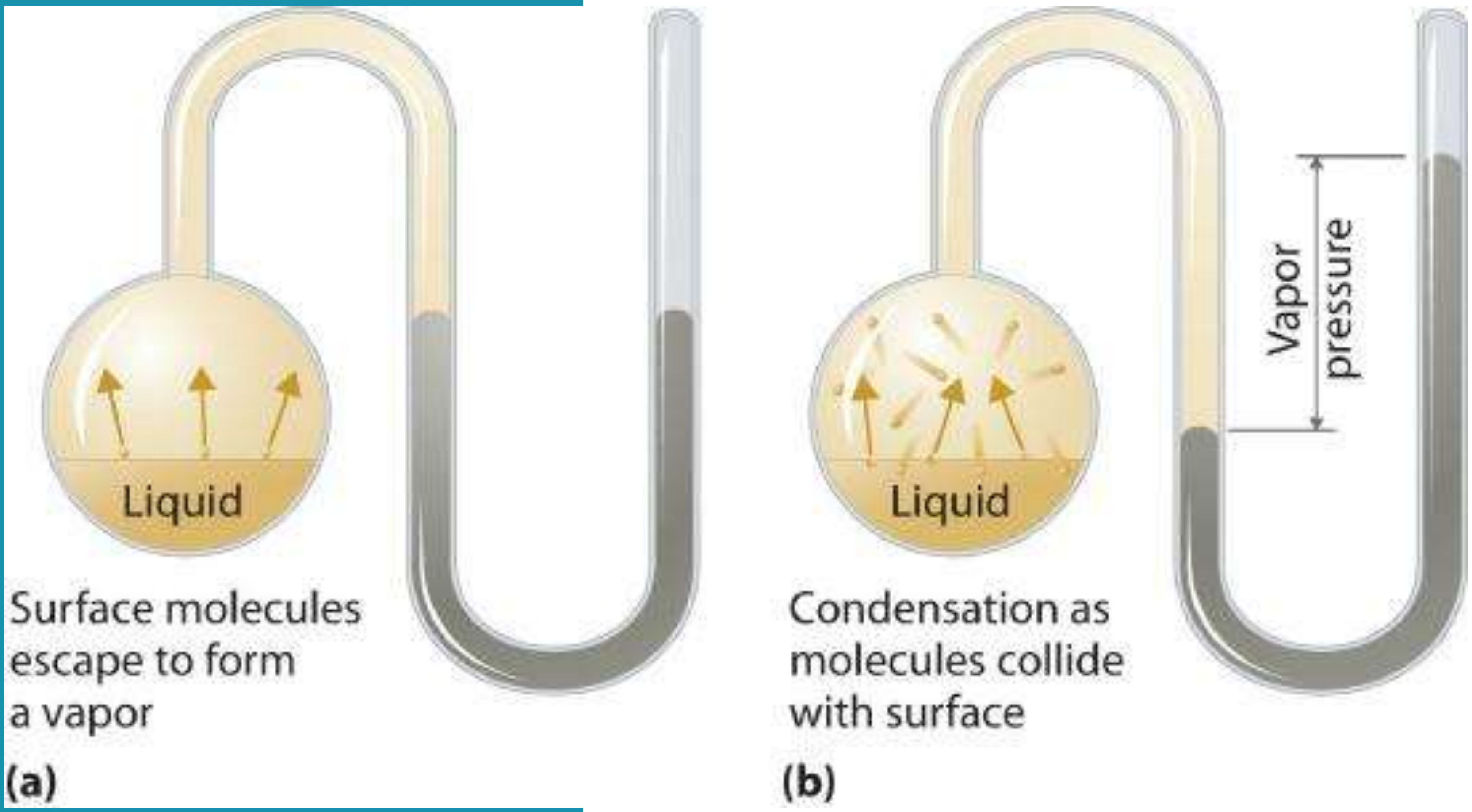
Psychrometric Chart

Graphic representation of the properties of air at various conditions



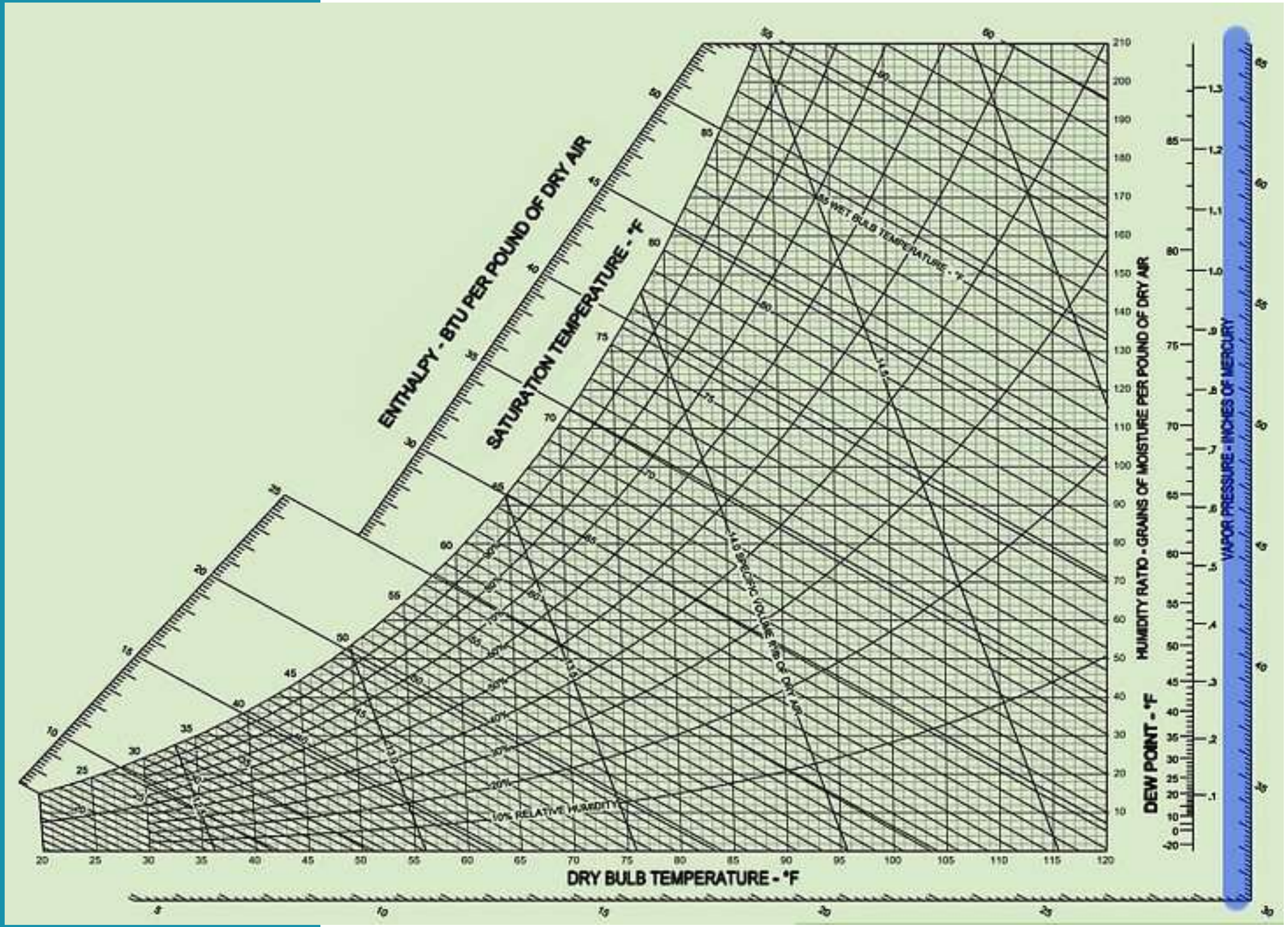
Relative Humidity

Vapor Pressure



Dew Point

Psychrometric Chart



Stakeholders

Patients

Physicians/Clinicians

Infection Control

Facility Staff

Why are Humidity Levels Important?

Comfort

Infection Control

Building Envelope

Equipment and supplies

Why are Humidity Levels Important?

Comfort

4 Environmental Factors

1. Air temperature
2. Radiant temperature
3. Humidity
4. Air Speed

2 Personal Factors

1. Metabolic Rate
2. Clothing Insulation

ASHRAE®

STANDARD

ANSI/ASHRAE Standard 55-2017
(Supersedes ANSI/ASHRAE Standard 55-2013)
Includes ANSI/ASHRAE addenda listed in Appendix N

Thermal Environmental Conditions for Human Occupancy

See Appendix N for approval dates.

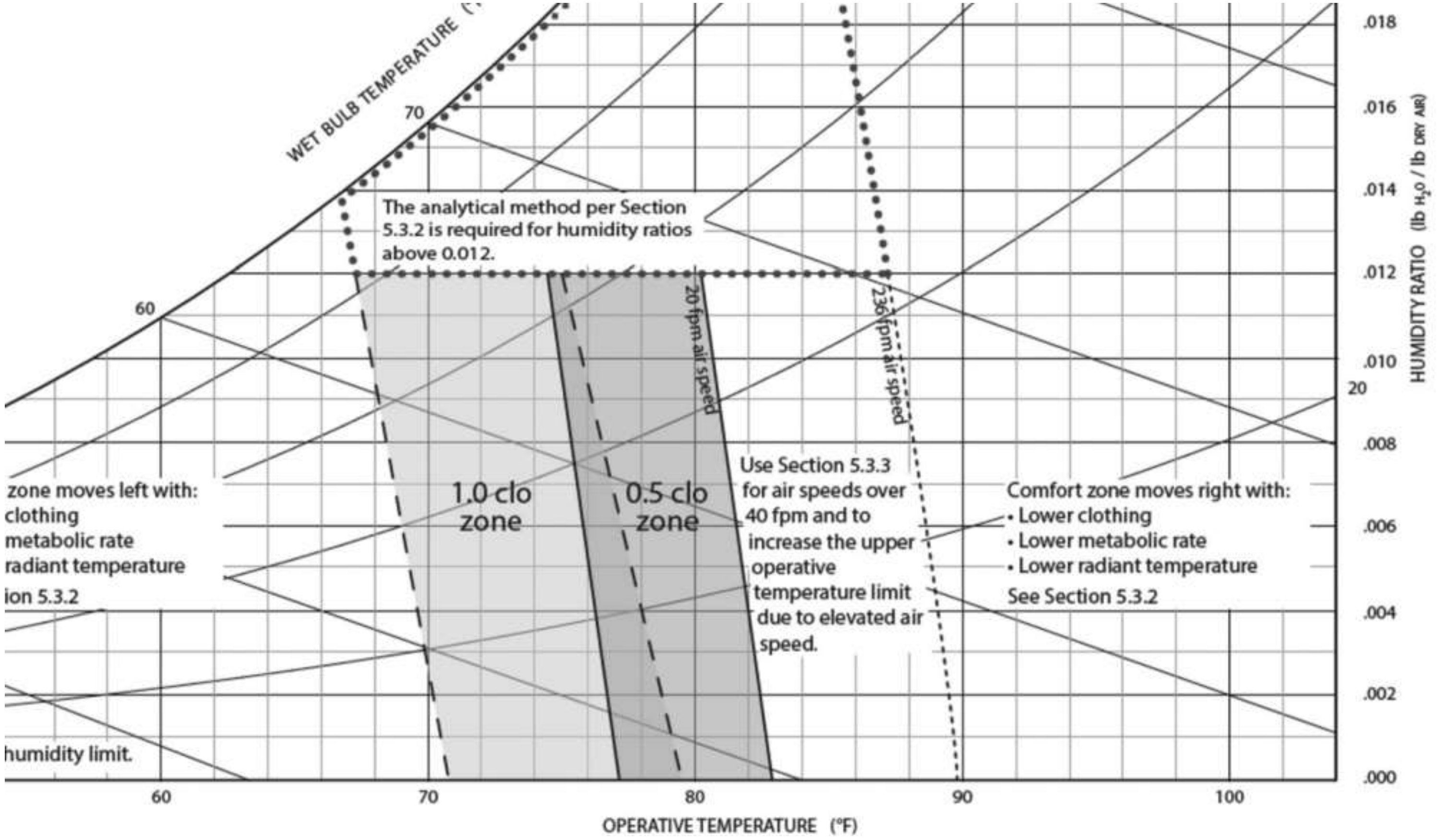
This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

 ISSN 1041-2336

Approved American National Standard ANSI www.ansi.org

Why are Humidity Levels Important?

Comfort



Why are Humidity Levels Important?

"Thermal Comfort in Health Care Settings"

Comfort

Thermal Comfort Factors	Medical and Support Staff	Patients	Visitors/Caregivers
Environmental: Air temperature, radiant temperature, air speed, humidity	Medical/support service specific varied control of the thermal environment: multi-occupant to individual, high air speeds in some medical procedures	Medical service specific Some control of the thermal environment by staff and caregivers	Common seasonal thermal adaptation
Personal: Metabolic rate, clothing insulation	Medical/support service specific Limited personal thermal adaptation Required clothing/uniform Activity: steady – transient	Medical service specific Gowning / bedding Personal thermal adaptation Standing, sitting, lying, sleeping, immobilized	Common seasonal thermal adaptation
Other: Psychological, work related, health-condition related	Mental stress, fatigue, workload, performance, arousal, health condition, well-being	Anxiety, length of stay, health/wellness condition, age, medication impact, healing, overall comfort	Anxiety, short stay, support

Mora,R.; Meteyer, M. Thermal Comfort in Health-Care Settings, ASHRAE Journal July 2019
https://www.nxtbook.com/nxtbooks/ashrae/ashraejournal_201907/index.php#/p/10

Why are Humidity Levels Important?

Infection Control

Mechanistic insights into the effect of humidity on airborne influenza virus survival, transmission and incidence

Linsey C. Marr[1], Julian W. Tang[2,3], Jennifer Van Mullekom[4] and Seema S. Lakdawala[5]

[1]Civil and Environmental Engineering, Virginia Tech, Blacksburg, VA 24061, USA
[2]Clinical Microbiology, University Hospitals Leicester NHS Trust, Leicester, UK
[3]Infection, Immunity and Inflammation, University of Leicester, Leicester, UK
[4]Statistics, Virginia Tech, Blacksburg, VA 24061, USA
[5]Microbiology and Molecular Genetics, University of Pittsburgh School of Medicine, Pittsburgh, PA 15219, USA

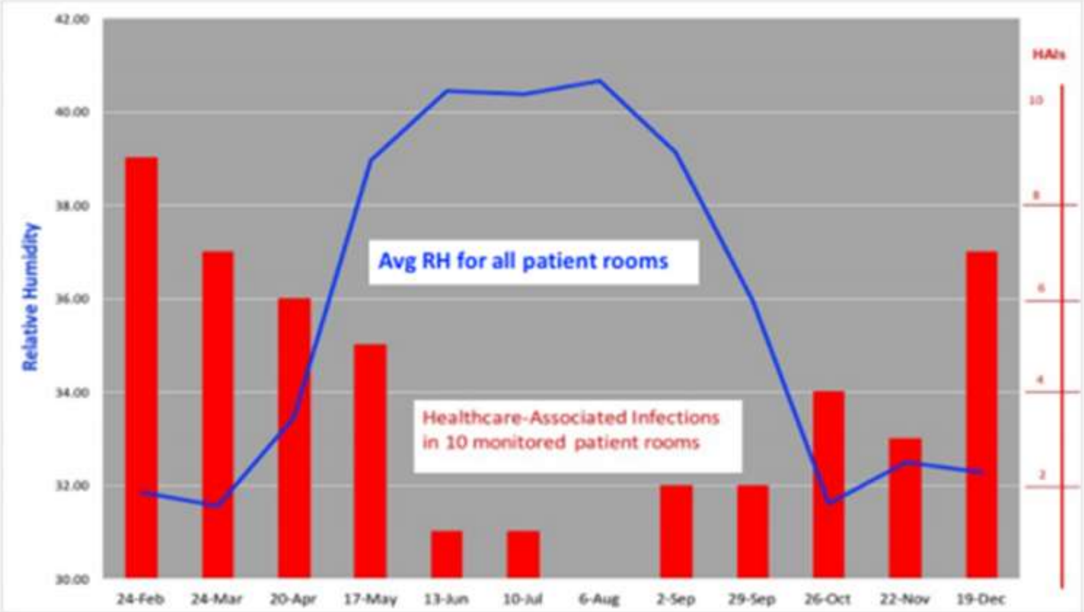
LCM, 0000-0003-3628-6891

Influenza incidence and seasonality, along with virus survival and transmission, appear to depend at least partly on humidity, and recent studies have suggested that absolute humidity (AH) is more important than relative humidity (RH) in modulating observed patterns. In this perspective article,

Is low indoor humidity a driver for healthcare-associated infections?

Stephanie Taylor, MD, M Arch, CIC, FRSPH(UK), CABE[1*], Walter Hugentobler, MD[2]

[1]Harvard Medical School, Boston, Massachusetts, United States
[2]Institut für Hausarztmedizin, Universität und Universitätsspital Zürich, Switzerland



Why are Humidity Levels Important?

Infection Control

The Journal of Infectious Diseases

MAJOR ARTICLE

IDSA Infectious Diseases Society of America · hivma hiv medicine association · OXFORD

Influenza Virus Infectivity Is Retained in Aerosols and Droplets Independent of Relative Humidity

Karen A. Kormuth,[1,a] Kaisen Lin,[3,a] Aaron J. Prussin II,[3] Eric P. Vejerano,[4] Andrea J. Tiwari,[3] Steve S. Cox,[3] Michael M. Myerburg,[2] Seema S. Lakdawala,[1] and Linsey C. Marr[3]

[1]Department of Microbiology and Molecular Genetics and [2]Department of Medicine, Division of Pulmonary, Allergy, and Critical Care Medicine, University of Pittsburgh School of Medicine, Pennsylvania; [3]Department of Civil and Environmental Engineering, Virginia Tech, Blacksburg; and [4]Department of Environmental Health Sciences, University of South Carolina, Columbia

Pandemic and seasonal influenza viruses can be transmitted through aerosols and droplets, in which viruses must remain stable and infectious across a wide range of environmental conditions. Using humidity-controlled chambers, we studied the impact of relative humidity on the stability of 2009 pandemic influenza A(H1N1) virus in suspended aerosols and stationary droplets. Contrary to the prevailing paradigm that humidity modulates the stability of respiratory viruses in aerosols, we found that viruses supplemented with material from the apical surface of differentiated primary human airway epithelial cells remained equally infectious for 1 hour at all relative humidities tested. This sustained infectivity was observed in both fine aerosols and stationary droplets. Our data suggest, for the first time, that influenza viruses remain highly stable and infectious in aerosols across a wide range of relative humidities. These results have significant implications for understanding the mechanisms of transmission of influenza and its seasonality.

Keywords. Influenza virus, relative humidity, rotating drum, aerosol, mucus, respiratory airway cells, transmission.

Influenza viruses are highly successful pathogens that emerge every winter in temperate regions. Epidemiologically successful influenza viruses must replicate efficiently in humans and transmit via the airborne route [1]. Coughing, talking, and exhaling can release aerosols and droplets of varying sizes containing respiratory fluid and viral particles [2–7]. The spread of influenza virus by either aerosol transmission (inhalation of infectious particles) or fomite transmission (self-inoculation from a contaminated surface) requires that influenza virus remain infectious in a variety of environmental conditions [8].

The risk of airborne disease transmission to a naive host is

of influenza virus infections, particularly in temperate regions [11, 12], that coincide with seasonal variations in temperature and absolute humidity [13–16]. Relative humidity (RH) can affect airborne transmission of influenza virus, as shown in the guinea pig model with deficient transmission at mid-range and very high RHs [9]. A partial explanation for this observation may be biological inactivation of influenza virus in aerosols at mid-range RHs, as suggested by the results of studies performed primarily in the 1960s [17–22]. We and others have previously shown that the presence of exogenous proteins in the virus solution can alter the pattern of viral decay in large stationary droplets in response to RH [23] and can prolong the viability of viruses on surfaces [24,

High Temperature and High Humidity Reduce the Transmission of COVID-19

Jingyuan Wang, Ke Tang, Kai Feng and Weifeng Lv*

March 9, 2020

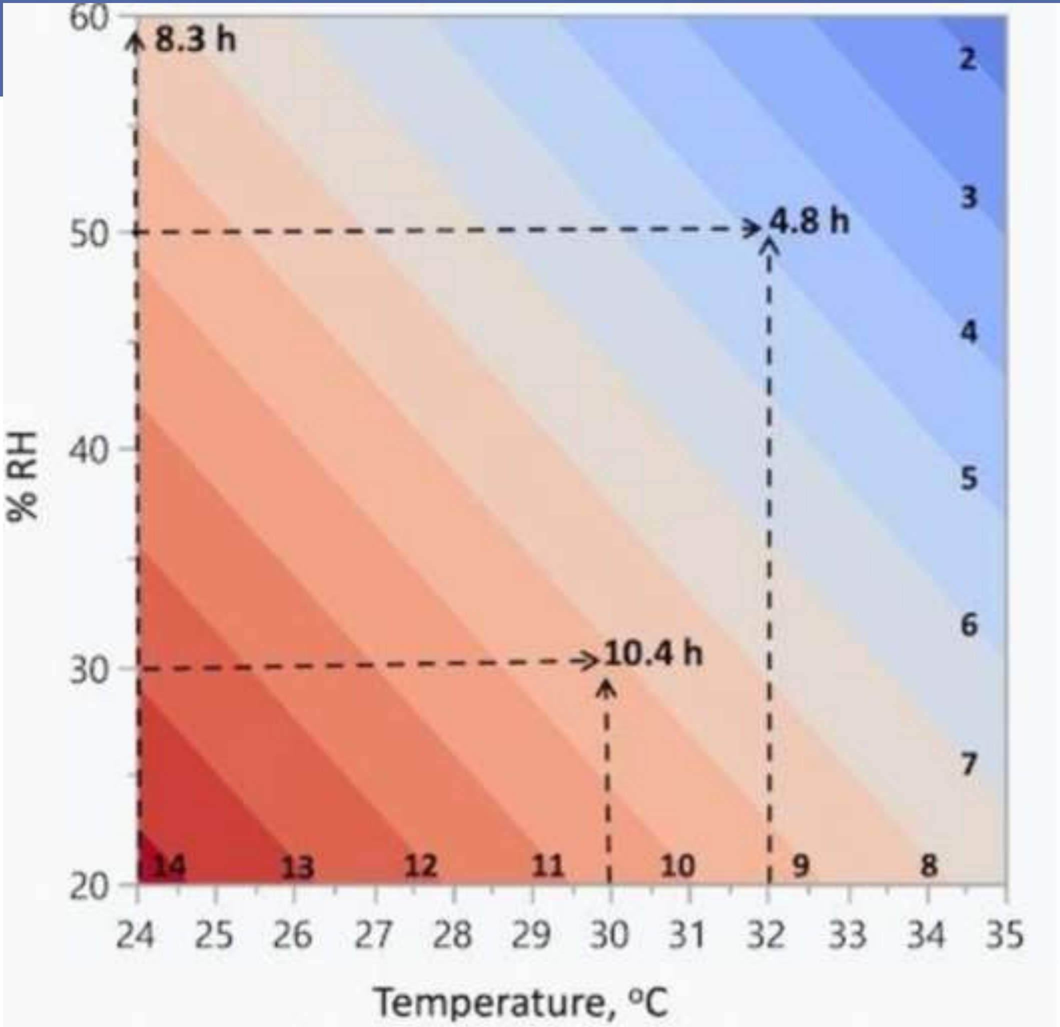
Abstract. This paper investigates how air temperature and humidity influence the transmission of COVID-19. After estimating the serial interval of COVID-19 from 105 pairs of the virus carrier and the infected, we calculate the daily effective reproductive number, R, for each of all 100 Chinese cities with more than 40 cases. Using the daily R values from January 21 to 23, 2020 as proxies of non-intervened transmission intensity, we find, under a linear regression framework for 100 Chinese cities, high temperature and high relative humidity significantly *reduce* the transmission of COVID-19, respectively, even after controlling for population density and GDP per capita of cities. One degree Celsius increase in temperature and one percent increase in relative humidity lower R by 0.0383 and 0.0224, respectively. This result is consistent with the fact that the high temperature and high humidity significantly reduce the transmission of influenza. It indicates that the arrival of summer and rainy season in the northern hemisphere can effectively reduce the transmission of the COVID-19.

Why are Humidity Levels Important?

Infection Control

DHS chart for COVID-19 surface stability

https://www.dhs.gov/science-and-technology/sars-calculator

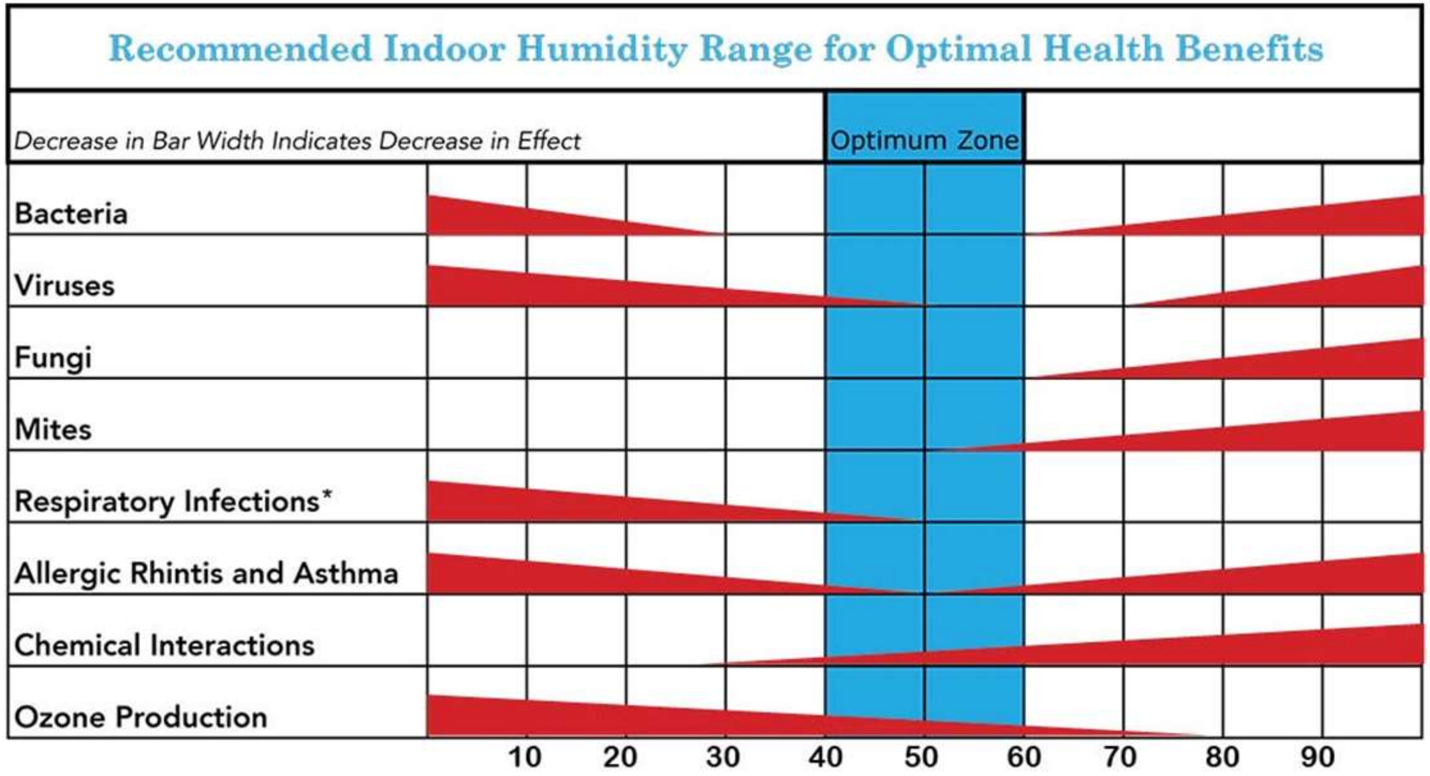


Why are Humidity Levels Important?

Infection Control

Sterling Chart

- ASHRAE Handbook
- Most referenced in HVAC
- Findings are being challenged
- RANGE 40-60% suggested practice



Source:
Arundel, Anthony V., Elia M. Sterling, Judith H. Biggin, and Theodor D. Sterling. "Indirect Health Effects of Relative Humidity in Indoor Environments." Environmental Health Perspectives 65 (1986): 351-61. Web.

*Insufficient Data Above 50% Relative Humidity

Why are Humidity Levels Important?

Building Envelope

Why are Humidity Levels Important?

Equipment and supplies

Equipment
- Not below 30%
- Electrostatic Discharge
- Integrated circuit damage

Supplies
- Not below 30%
- The Joint Commission suggests an ideal level for sterile supplies of 50% with a "Never exceed of 70%

Codes, Guidelines, and Accreditation Requirements

Codes

- Wisconsin Administrative Code
- IBC, IMC, etc…

Accreditations

- AAAASF, ABCS, AORN, CMS, TJC, etc…

Standards and Guidelines

- ASHRAE
- NFPA
- FGI
- CDC
- ASHE

Codes, Guidelines, and Accreditation Requirements

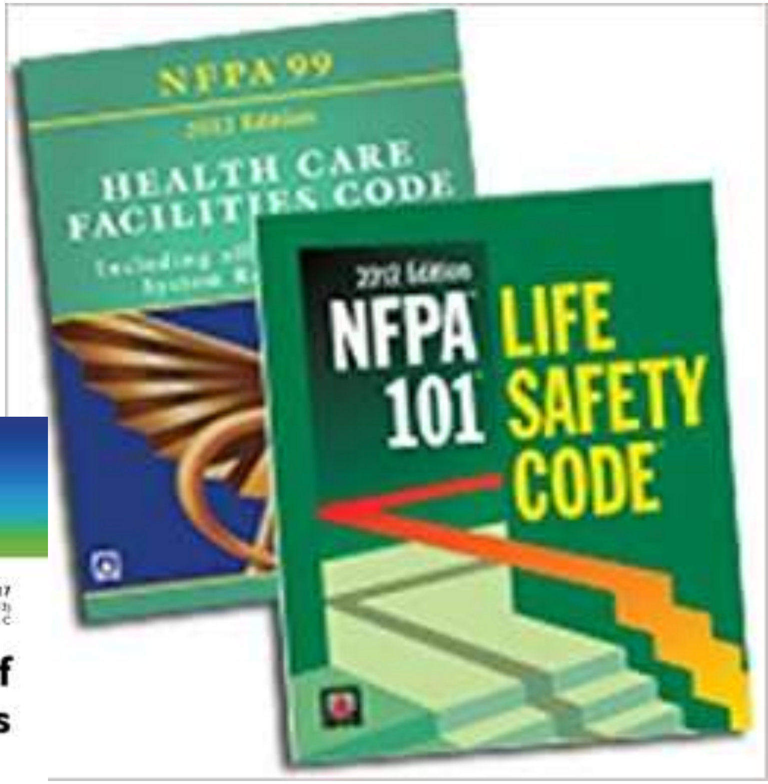
Wisconsin Administrative Code

Department of Safety and Professional Service

SPS 364.0300 (HVAC) Health care facilities

FGI Guidelines Chapter 6

ASHRAE Standard 170



Codes, Guidelines, and Accreditation Requirements

Humidity Requirements
ASHRAE Standard 170

- Continuous Maintenance
- Standing Standard Committee SSPC 170
- Ranging Committee Membership
- Code – Minimum requirement
- Not best practice
- Design Standard not an Operational Standard

STANDARD

ANSI/ASHRAE/ASHE Standard 170-2017
(Supersedes ANSI/ASHRAE/ASHE Standard 170-2013)
Includes ANSI/ASHRAE/ASHE addenda listed in Appendix C

Ventilation of Health Care Facilities

See Appendix C for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the ASHE Board of Directors, and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

© 2017 ASHRAE ISSN 1041-2336

ASHRAE ASHE ANSI

Codes, Guidelines, and Accreditation Requirements

ANSI/ASHRAE/ASHE Standard 170-2017

Table 7.1 Design Parameters—Hospital Spaces

Function of Space	Pressure Relationship to Adjacent Areas (n)	Minimum Outdoor ach	Minimum Total ach	All Room Air Exhausted Directly to Outdoors (j)	Air Recirculated by Means of Room Units (a)	Design Relative Humidity (k), %	Design Temperature (l), °F/°C
SURGERY AND CRITICAL CARE							
Critical and intensive care	NR	2	6	NR	No	30–60	70–75/21–24
Delivery room (Caesarean) (m), (o)	Positive	4	20	NR	No	20–60	68–75/20–24
Emergency department decontamination	Negative	2	12	Yes	No	NR	NR
Emergency department exam/treatment room (p)	NR	2	6	NR	NR	Max 60	70–75/21–24
Emergency department public waiting area	Negative	2	12	Yes (q)	NR	Max 65	70–75/21–24
Intermediate care (s)	NR	2	6	NR	NR	Max 60	70–75/21–24
Laser eye room	Positive	3	15	NR	No	20–60	70–75/21–24
Medical/anesthesia gas storage (r)	Negative	NR	8	Yes	NR	NR	NR
Newborn intensive care	Positive	2	6	NR	No	30–60	72–78/22–26
Operating room (m), (o)	Positive	4	20	NR	No	20–60	68–75/20–24
Operating/surgical cystoscopic rooms (m), (o)	Positive	4	20	NR	No	20–60	68–75/20–24
Procedure room (o), (d)	Positive	3	15	NR	No	20–60	70–75/21–24

Footnote

k. The RH ranges listed are the minimum and/or maximum allowable at any point within the design temperature range required for that space.

Codes, Guidelines, and Accreditation Requirements

ASHRAE Standard 170 Table 7.1 Summary of RH Ranges

# of Spaces	Relative Humidity
9	20-60%
4	30-60%
1	40-60%
22	max 60%
2	max 65%
43	No requirements

Codes, Guidelines, and Accreditation Requirements

20% to 60% RH
Cesarean Delivery room
Emergency department trauma/resuscitation room
Laser eye room
Operating room
Operating/surgical cystoscopic rooms
Phase I PACU and Phase II recovery
Procedure room
Treatment room
Gastrointestinal endoscopy procedure room

30% to 60% RH
Continued care nursery
Critical care patient care station
Neonatal intensive care
Newborn nursery

Codes, Guidelines, and Accreditation Requirements

40% to 60% RH	Max 65%
Wound Intensive Care (burn unit)	Emergency department public waiting area
	Physical therapy

Codes, Guidelines, and Accreditation Requirements

Examples of Max 60% (22 space types)
Nursery workroom
Patient room
General examination room
Imaging (diagnostic and treatment)
Treatment room
Pharmacy Services: Pharmacy Areas
Clean assembly/workroom

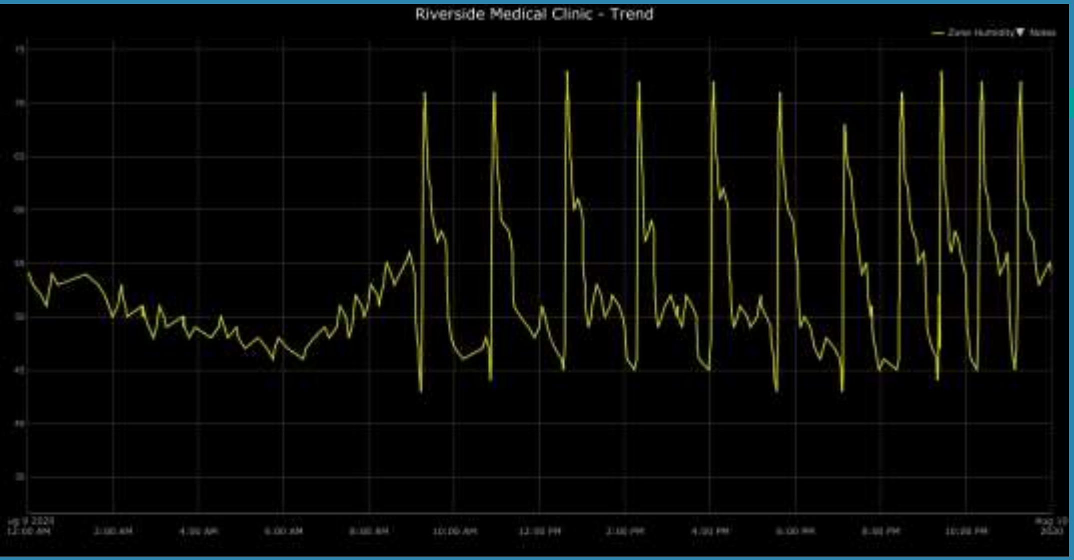
Examples of No Requirement (43 space types)
Patient care area corridor
Patient toilet room
PE anteroom
Sterile processing room
Bronchoscopy, sputum collection
Dialysis treatment area
Endoscope cleaning

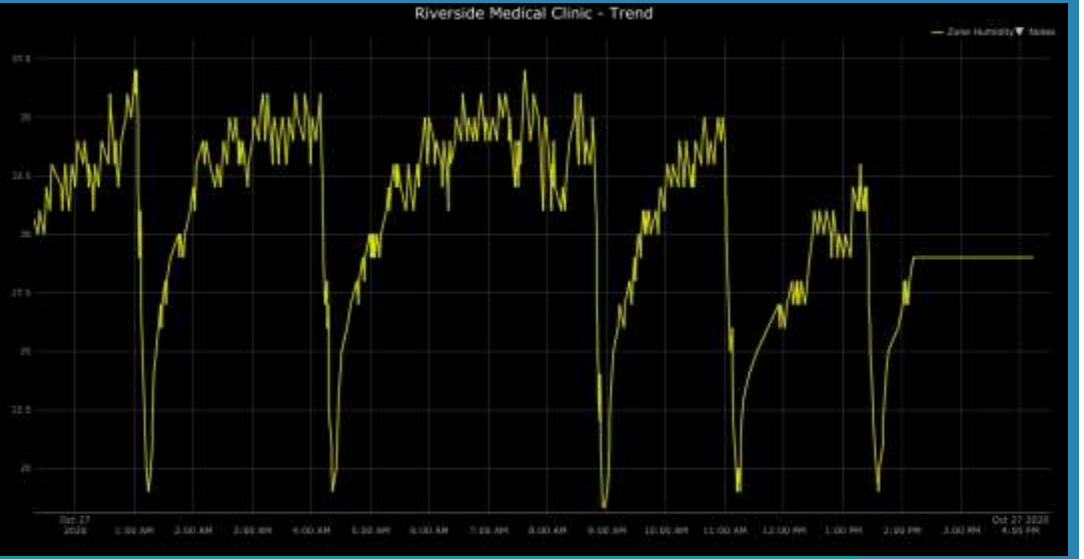
Codes, Guidelines, and Accreditation Requirements

ASHRAE Std 170 Subcommittee
- Reviewing Temps & RH's requirements
- Rooms of interest in potentially changing

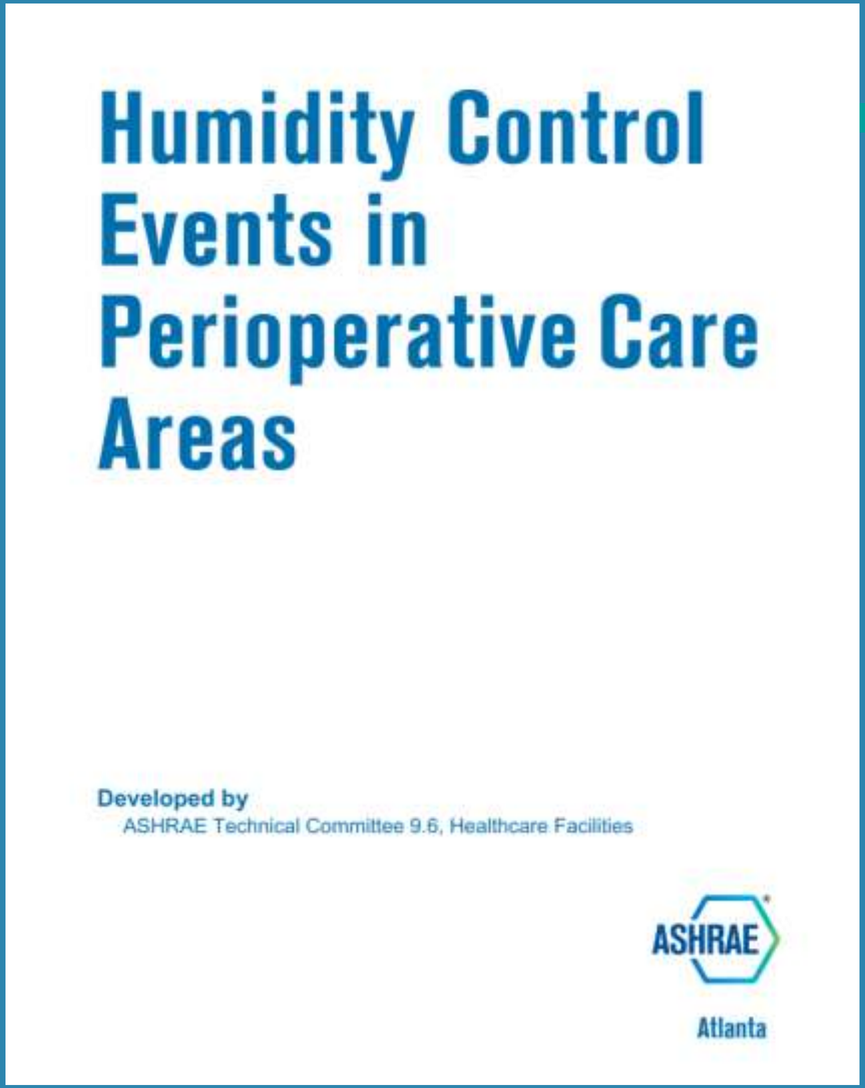
NURSING UNITS AND OTHER PATIENT CARE AREAS	Rh
All anteroom (2.1–2.4.2.3) (u)	NR
Combination AII/PE anteroom (2.2–2.2.4.5)	NR
Emergency department public waiting area (2.2–3.1.3.4)	Max 65
Sterile processing room (2.2–3.3.6.13)	NR
DIAGNOSTIC AND TREATMENT	
Bronchoscopy, sputum collection, and pentamidine administration	NR
Dialysis treatment area	NR
Nuclear medicine hot lab	NR
Nuclear medicine procedure room (2.2–3.6.1)	NR
Physical therapy	Max 65
PATIENT SUPPORT FACILITIES	
Laboratory work area, bacteriology (f), (v)	NR
Laboratory work area, biochemistry (f), (v)	NR
Laboratory work area, cytology (f), (v)	NR
Laboratory work area, general (f), (v)	NR
Laboratory work area, glasswashing (f)	NR
Laboratory work area, histology (f), (v)	NR
Laboratory work area, media transfer (f), (v)	NR
Laboratory work area, microbiology (f), (v)	NR
Laboratory work area, nuclear medicine (f), (v)	NR
Laboratory work area, pathology (f), (v)	NR
Laboratory work area, serology (f), (v)	NR
Laboratory work area, sterilizing (f)	NR
SUPPORT AREAS FOR NURSING UNITS AND OTHER PATIENT CARE AREAS	
Clean supply room (2.1–2.6.9.2)	NR
Clean workroom (2.1–2.6.9.1)	NR
Soiled workroom or soiled holding (2.1–2.6.10)	NR

Compliance Challenges





- Operating Rooms
- Sterile Compounding
- Decontamination
- Other
- Do you use the BAS system data trend logging?
- What do you do when the humidity is outside the range



Humidity Control Events in Perioperative Care Areas

Developed by
ASHRAE Technical Committee 9.6, Healthcare Facilities

ASHRAE

Atlanta

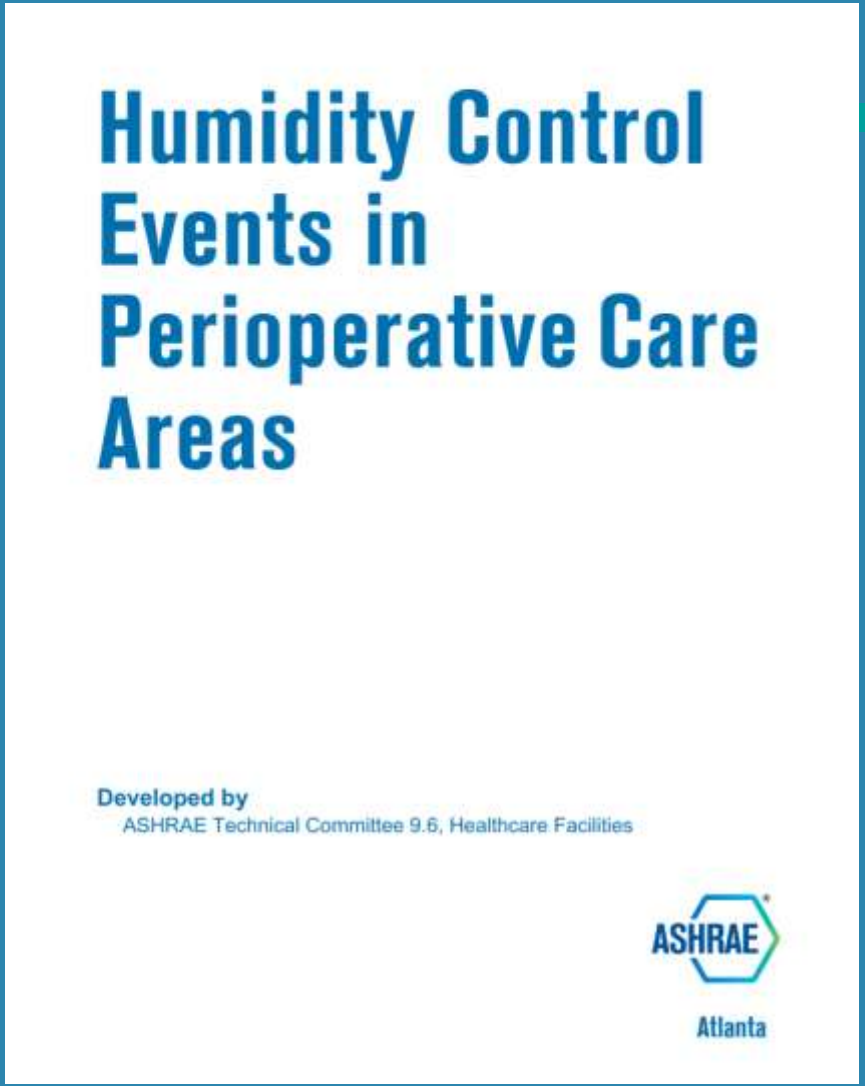
https://www.ashrae.org/file%20library/technical%20resources/bookstore/whitepaper_tc0906-humidcontroleventsinperiopcareareas.pdf

Compliance Challenges

For Operating Rooms

- Describes protocol for when RH is outside the desired range
- AVOID decision making during an event

Compliance Challenges


Humidity Control Events in Perioperative Care Areas

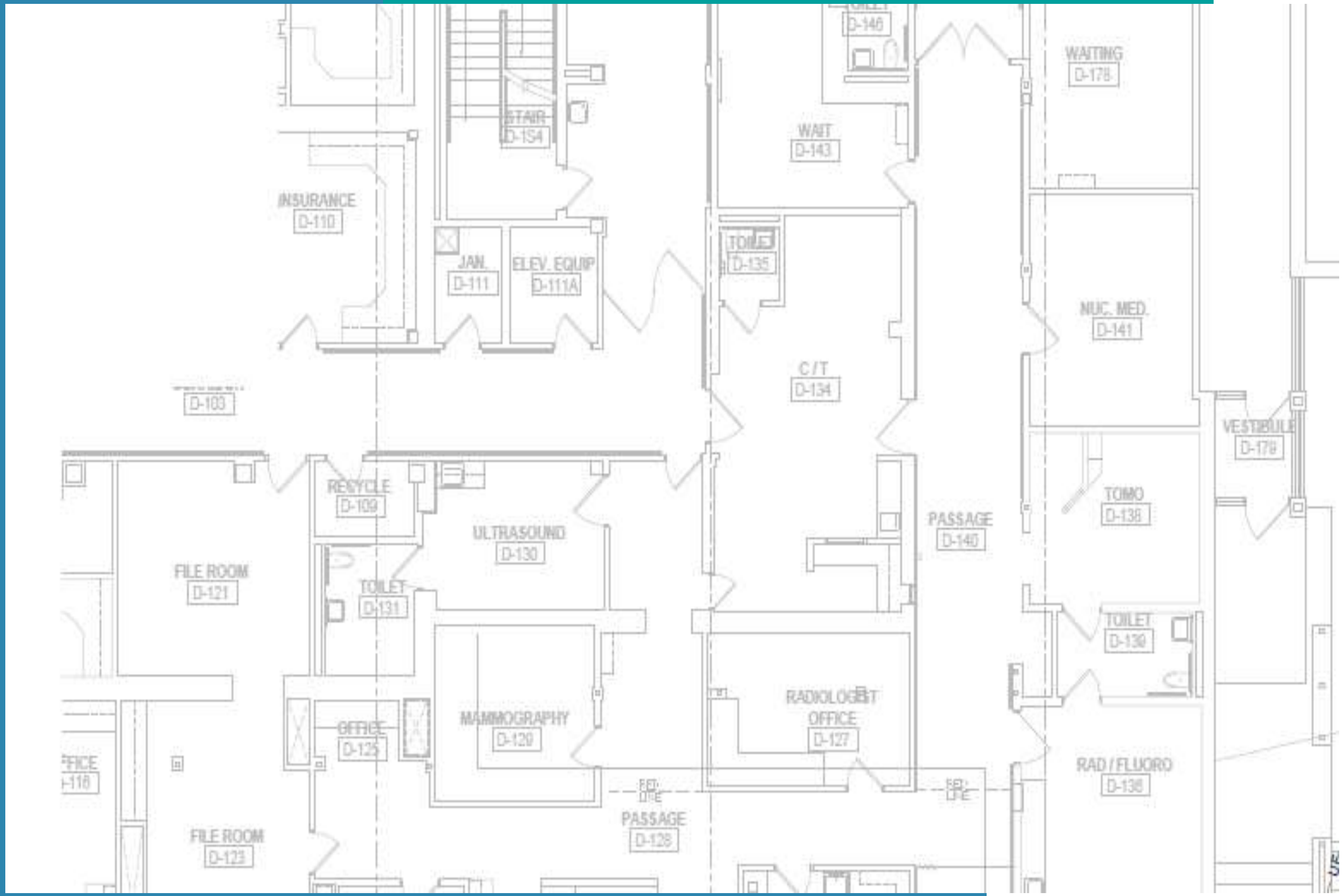
Developed by
ASHRAE Technical Committee 9.6, Healthcare Facilities

ASHRAE

Atlanta

https://www.ashrae.org/file%20library/technical%20resources/bookstore/whitepaper_tc0906-humidcontroleventsinperiopcareareas.pdf

- Establish Facilities Humidity Ranges
- Cross functional team
- Protocols for Humidity Events
- Response consistent with severity / consistency
  - ✓ How far out of range
  - ✓ How long out of range
  - ✓ What is risk (comfort, infection, building, supplies)
- Follow protocol and document response



CONTROLLABILITY BETWEEN SPACES

- Vapor Pressure
- Barriers
- HVAC System Zoning

Humidification Equipment

- Steam Dispersion
- Pad/Adiabatic

Steam technologies

Isothermals add steam

Adiabatic

Adding water droplets

Dehumidification

- Cool/Reheat as part of HVAC system
- Desiccant
- Exhaust/OA

Summary thoughts

- Humidity Impacts Comfort, Infection Control, Building Envelope , Equipment, and Supplies
- Additional research is needed
- Standards and guidelines have changed over the years and likely to change again
- Don’t use code requirements as Design Criteria
- 40-60% “best” guidance for most areas
- Have appropriate protocols & response plans for humidity control events

References and Resources

- ANSI/ASHRAE/ASHE Standard 170
- FGI Guidelines for Design and Construction of Hospitals
- The Joint Commission various references
- NFPA -99 Healthcare Facilities Code
- Various CDC guidelines
- AHRI Documents

ssaunders@henneman.com

mmeteyer@erdman.com