

The Importance of Humidity in Modern Buildings

AHRI Humidifiers Product Section

January 15, 2019

Presenters

- **Jeremy Wolfe**
Head of Sales and Marketing
Carel USA, Inc.
- **Matt Nowak**
Director of Sales
Armstrong International
- **Graham Holmes**
Technical Product Manager
Condair Limited

What is the importance of humidity control within buildings?

How much humidity does my building need?

What is humidity's impact on health and wellness?

Can humidity levels affect energy consumption?

Can humidity affect quality of products?

Can adding humidity bring greater value to my client?

How does humidity play a role in the industrial process?

Agenda

1. Introduction

- Humidity Terminology
- Psychrometric Chart
- Why Buildings Dry Out

2. Equipment/Machines and Humidity

- Humidification Applications

3. Human Health and Humidity

- Humidity and the Body
- Humidity and Health
- Applications for Occupants

4. Questions

What is humidity?

Humidity is the water vapor contained in the air.

It is the water content of the air.

Air is a mixture of:

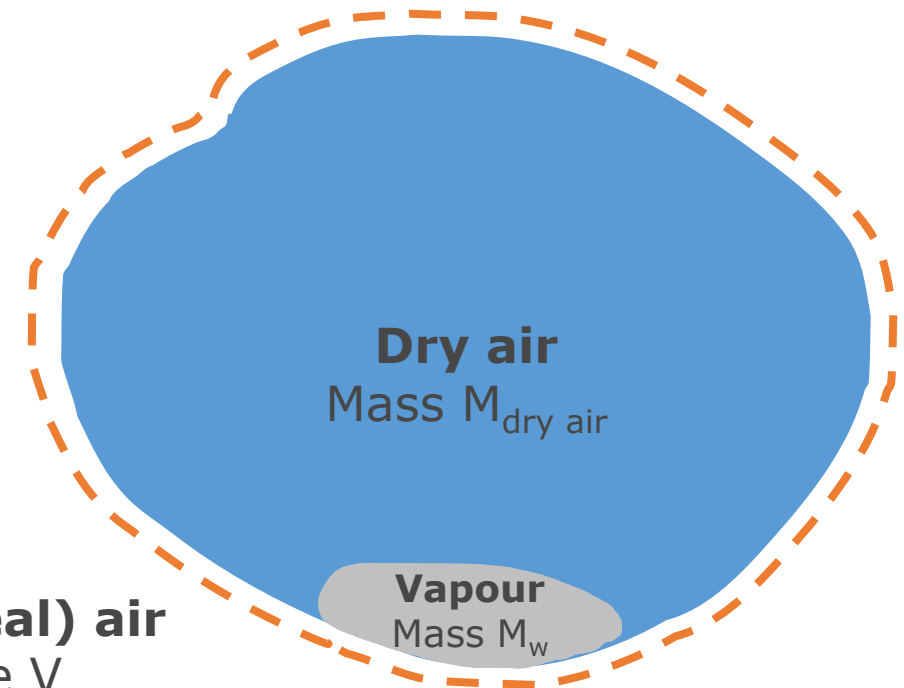
- Oxygen (O₂): approx. 21%
- Nitrogen (N₂): approx. 78%
- Other volatile compounds (approx. 1%):
 - water vapor (some grams per kg of air or grains per lbs)
 - rare gases: Argon (Ar), etc.

Humid (real) air

Volume V

Temperature t

Pressure p



What is humidity?

Measured in “Absolute” or “Relative” terms

- Absolute Humidity

- Mass of water in particular volume of air
- Expressed as mass ($\text{grains/lb}_{\text{da}}$ or $\text{g}_w/\text{kg}_{\text{da}}$)

- Relative Humidity

- Amount of water vapor in the air relative to how much it can hold at a given temperature (%)

Psychrometric Chart

"E" - enthalpy

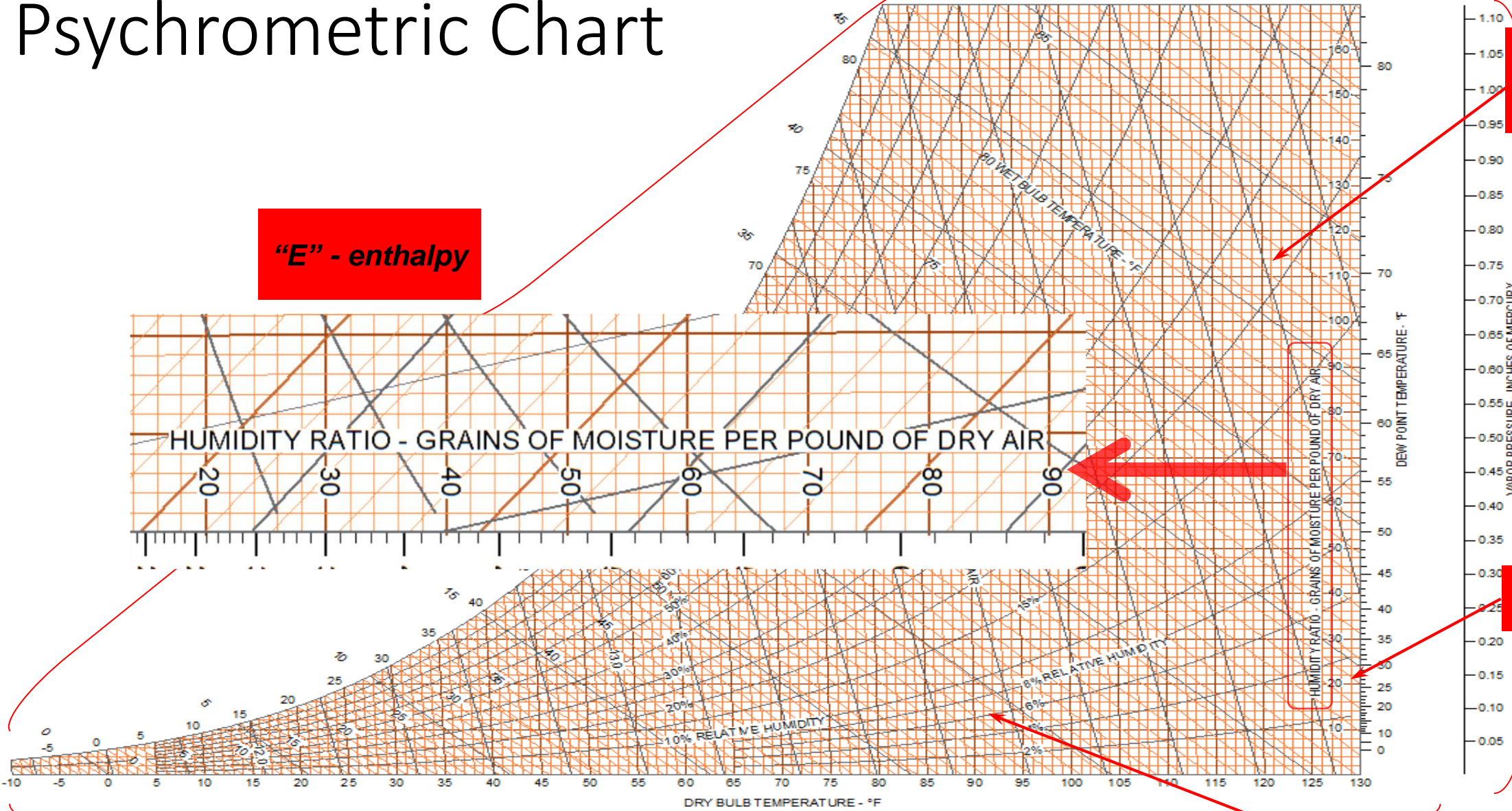
Specific volume

Humidity ratio

t_{wb}

Relative humidity

t_{db}

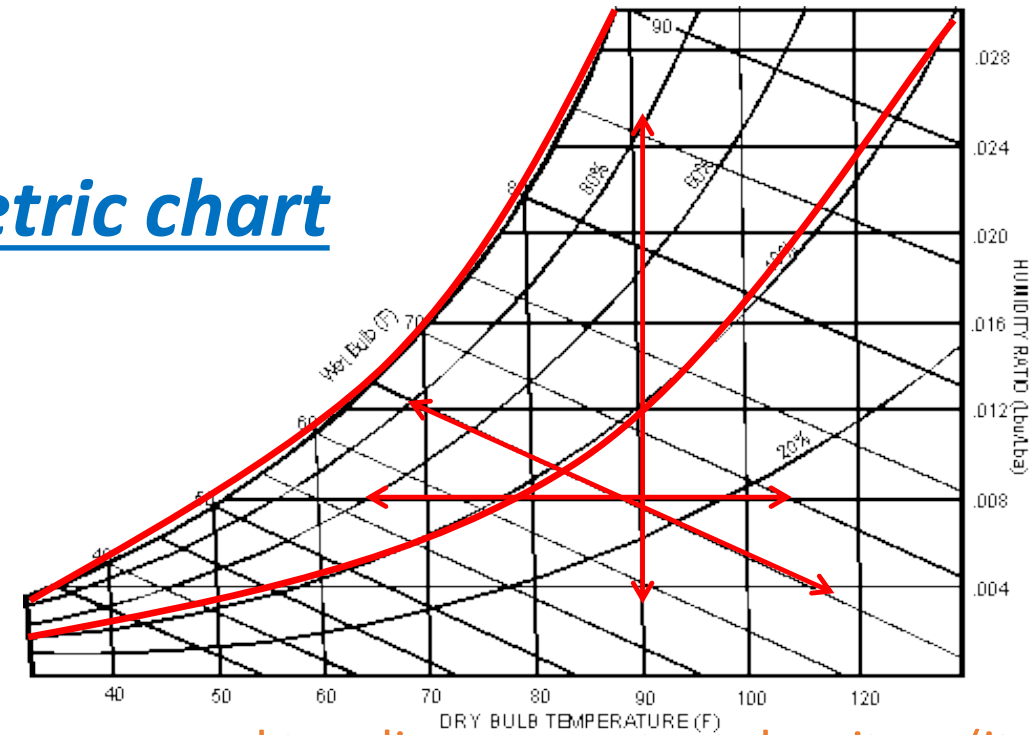


Psychrometric Chart

Lines on the psychrometric chart

The psychrometric chart has the following lines and curves:

- Isotherms → Lines at constant temperature.
- Isethalpic lines → Lines at constant enthalpy.
- Isochores → Lines at constant volume. Each isochore can correspond to a line at constant density ρ (it is usually assumed that $\rho = 1.2 \text{ kg/m}^3 \Rightarrow v = 0.833 \text{ m}^3/\text{kg}$).
- Limit saturation curve.
- Curve at constant relative humidity → Traced by joining points with the same relative humidity.

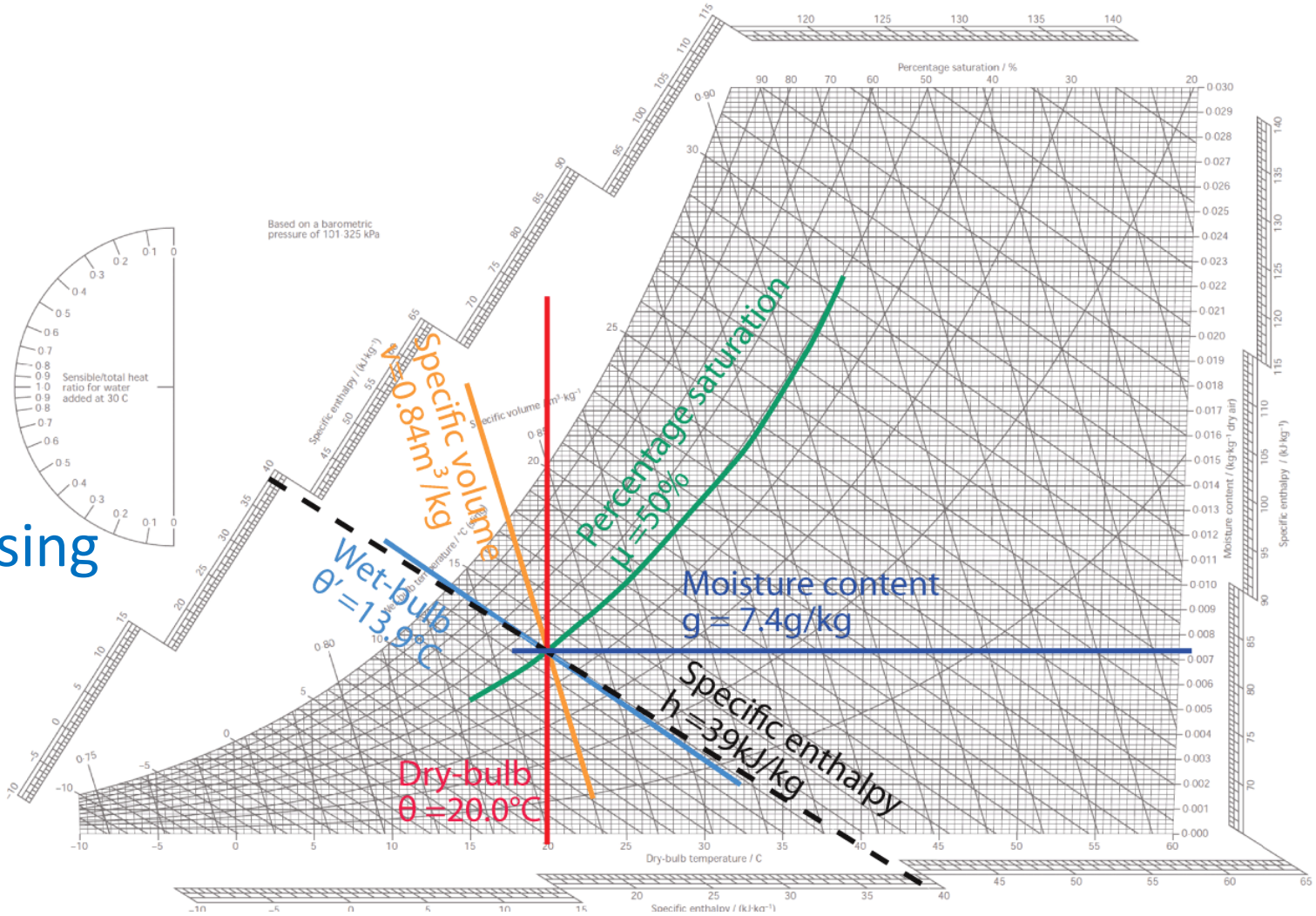


Psychrometric Chart

Directional Process

Each directional line on the chart symbolizes a process.

This can look a bit confusing at first glance



Psychrometric Chart

Directional Process

Each directional line on the chart symbolizes a process.

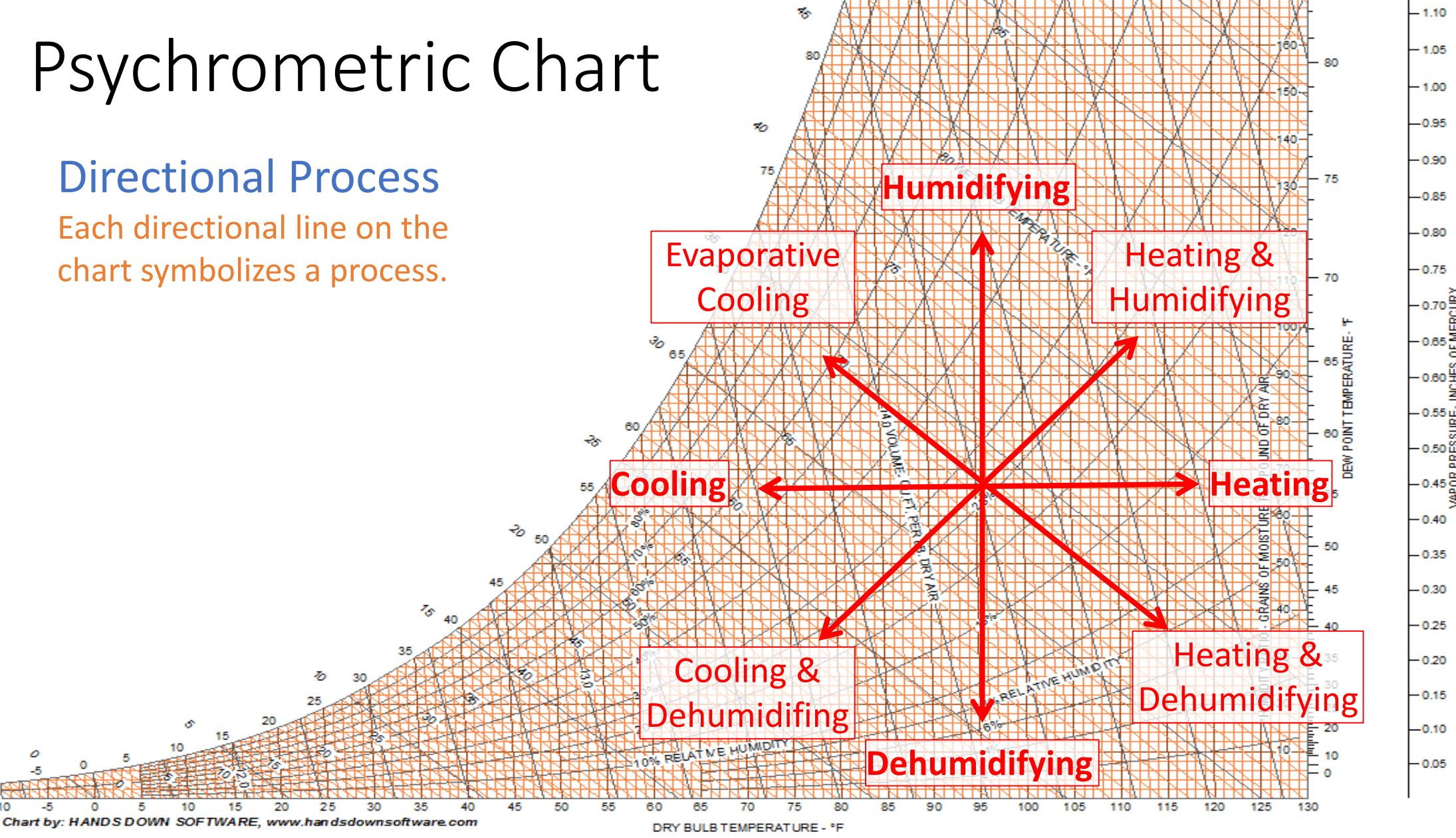
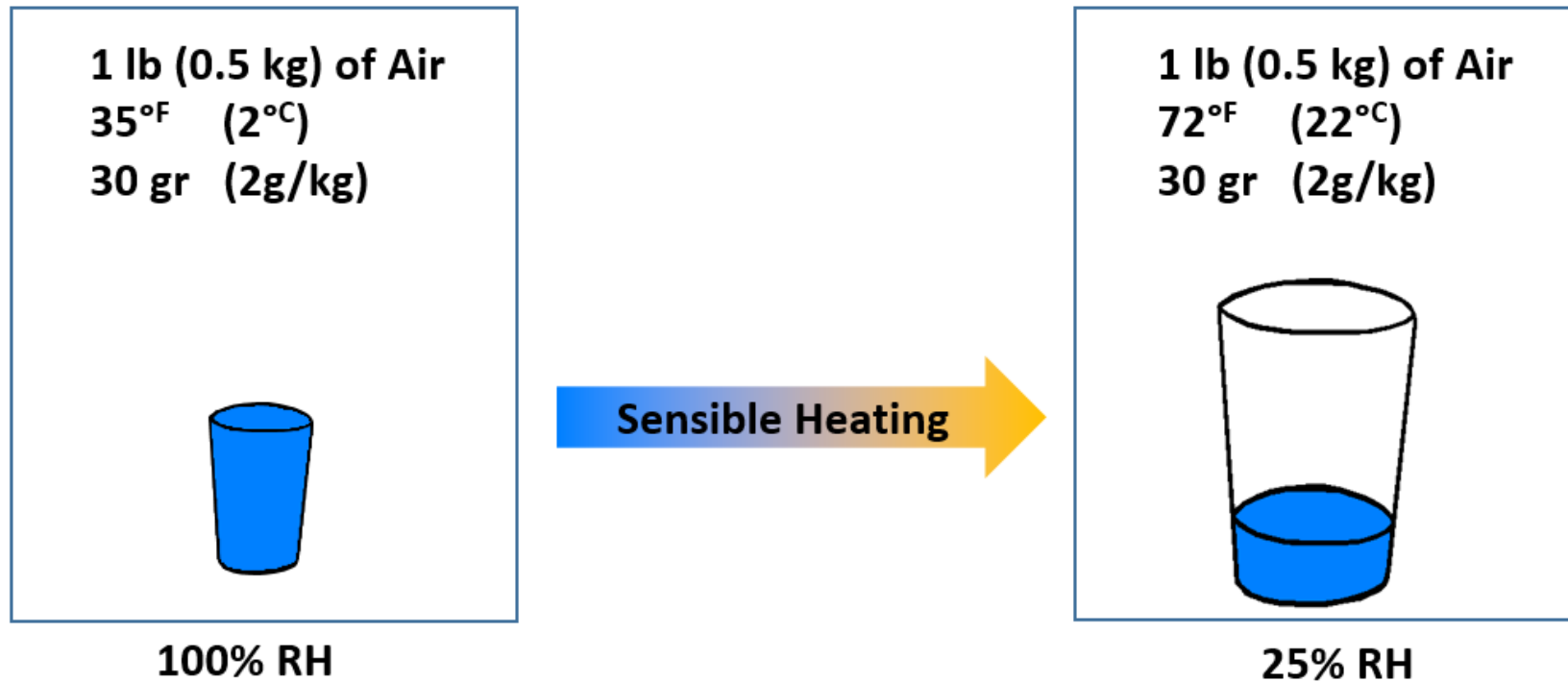


Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com

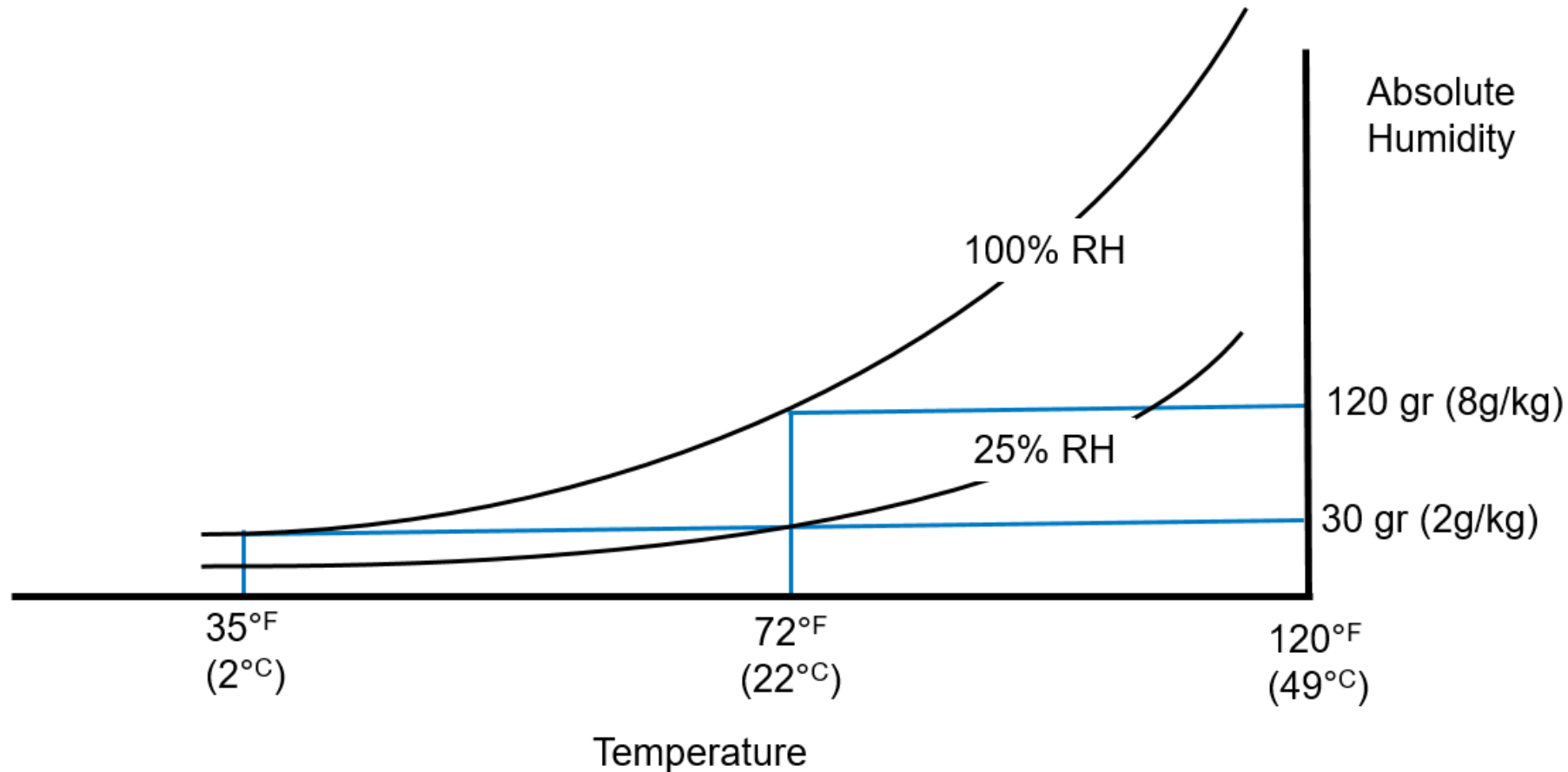
Why Do Buildings Dry Out?

- Absolute Humidity is measured by mass (gr/lb, g/kg)
- Relative Humidity is relative to temperature (%)



Why Do Buildings Dry Out?

- Humidity vs. Temperature



Why Do Buildings Dry Out?

Outside air with low absolute humidity dries building

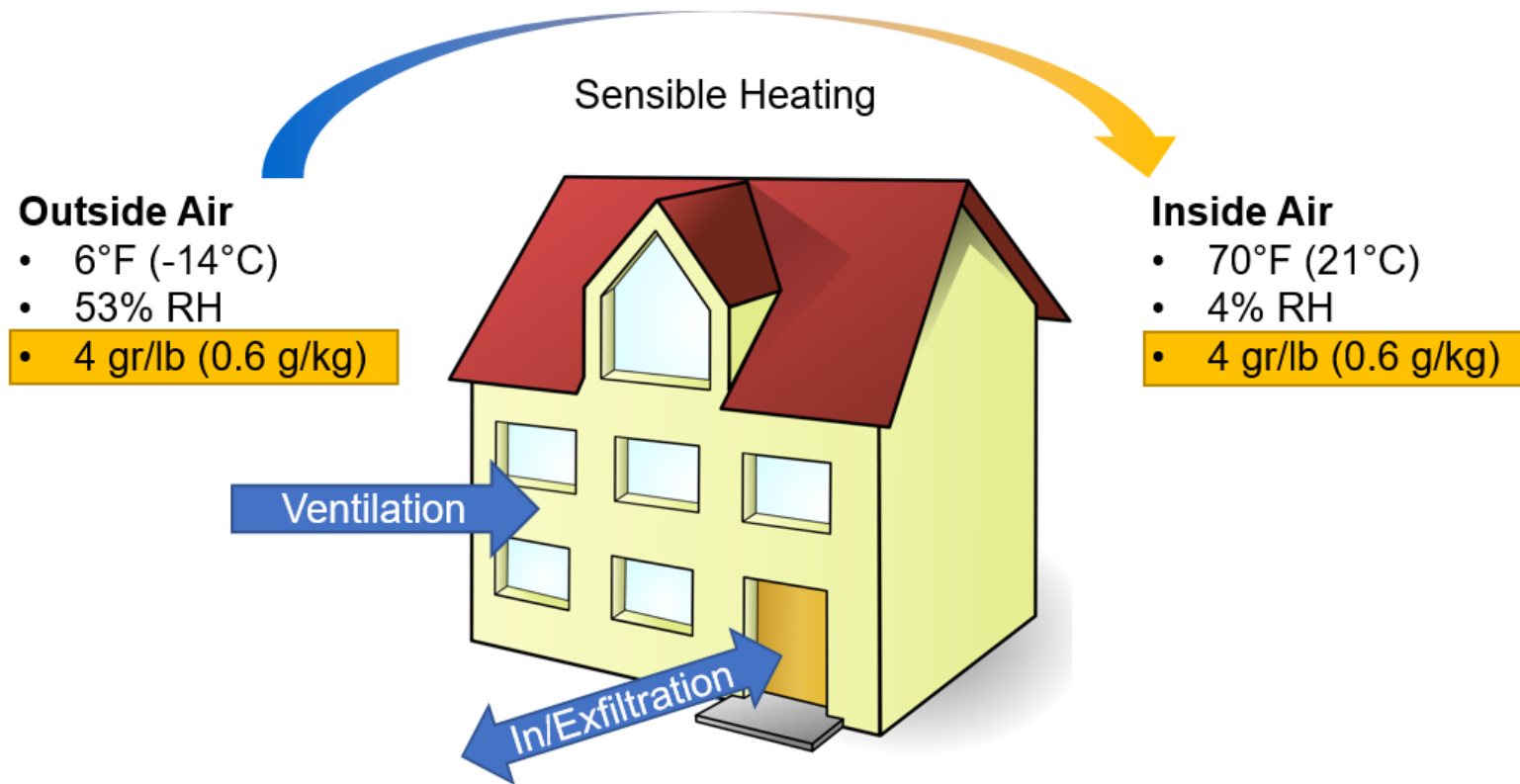


Image: Free Stock Photos 14413

Humidification Applications

Humidity Solutions for Commerce and Industry

Humidity for Process



Humidity for Occupants



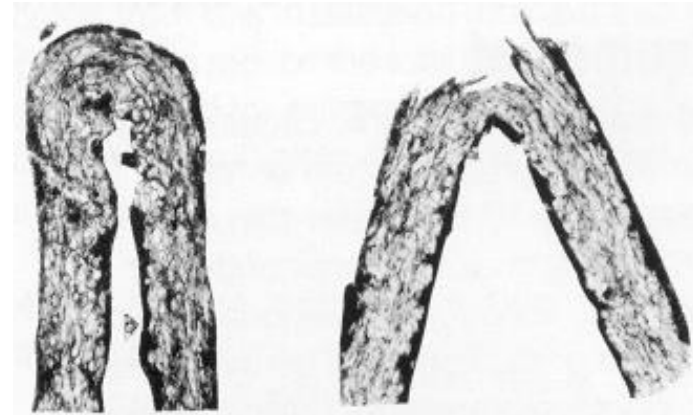
Applications: Preserves Hydrosopic Materials

- Paper / Paintings / Wood

- Canvas Can Expand And Contract
- Cracking Or Breaking At Creases
- Furniture / Flooring Defects
- Gluing Failures
- Chills



- Leather / Skin



Applications: Humidity Affects Drying



- Vapor pressure differential drives moisture flow
- Quality concerns:
 - Shrinkage
 - Adhesion
 - Runs / drips
 - Inclusions
- Example Applications:
 - Automotive
 - Furniture
 - Leather

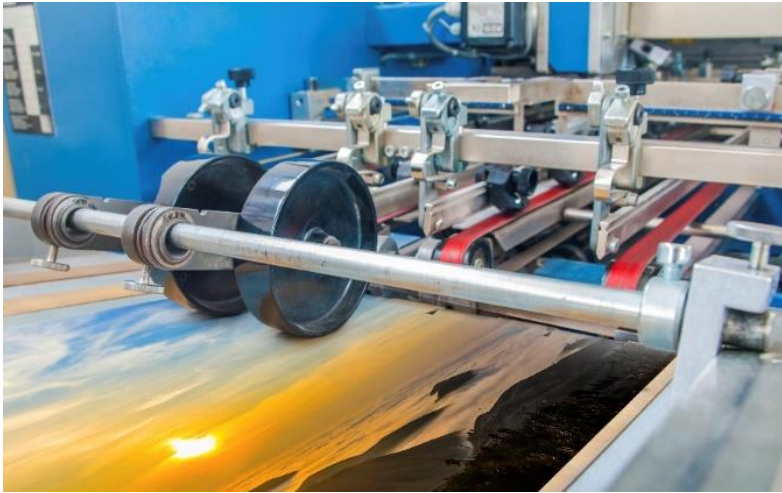
Applications: Humidity Affects Materials



- Moisture absorbs/desorbs in hygroscopic materials
- Quality concerns:
 - Dimensional instability
 - Cracks / deterioration
 - Delamination of coatings
- Example Applications:
 - Printing
 - Woodworking
 - Museums and artifacts
 - Instruments
 - Dust suppression



Applications: Humidity in Printing



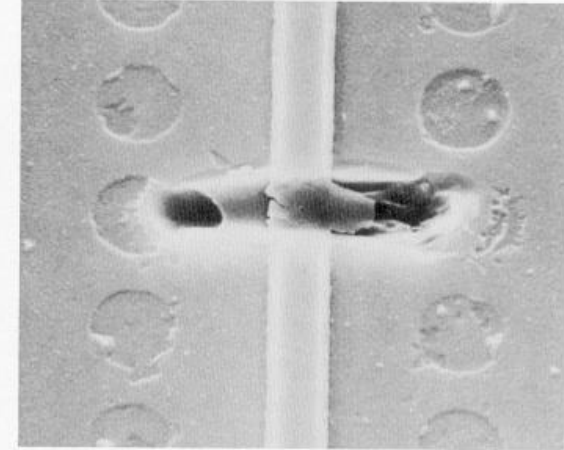
- **Conditions:**
 - 76-80°F (24–27°C), 43–47 ±2% RH
- **Static electricity:**
 - Paper cling
 - Ink mist control
- **Drying:**
 - Ink run / smudge
 - Ink bleed to other prints
- **Hygrosopic materials:**
 - Paper distortion / misregistering
 - +3% moisture, +0.2% size
 - Paper ordered to match pressroom RH

Video: Courtesy Gary Berlin

Applications: Humidity Dissipates Static

- **Electrostatic Discharge**
 - Release of static electricity when two objects come into contact
- **Minimized by adding humidity**

Figure 7-1.
Effect of humidity on electrostatic voltages



Integrated circuit damaged by ESD.
(Photo courtesy of Motorola Semiconductor, Inc.)



Applications: Humidity Dissipates Static



- Moisture provides conductive path for electrons
- Quality concerns:
 - Electrical component damage
 - Static cling
 - Spray pattern changes / paint defects
 - Ignition of flammable substances
- Example Applications:
 - Electronics
 - Printing and Textiles
 - Chemicals

Applications: Humidity Dissipates Static

Electrostatic Voltages		
	10%-20% RH	65%-90% RH
Walking Across Carpet	35,000	1,500
Walking Over Vinyl Floor	12,000	250
Worker at Bench	6,000	100
Vinyl Envelopes for Work Instructions	7,000	600
Common Poly Bag Picked Up From Bench	20,000	1,200
Common Chair Padded with Polyurethane Foam	18,000	1,500

Humidity, Health, and You

How Does Humidity Affect People?

Human Body Response:

- Human body is ~60% water
- Body doesn't sense moisture well

Ambient Air Humidity Affects the Body:

- Eyes
- Skin
- Throat
- Nose
- Immune System
- Body Hydration



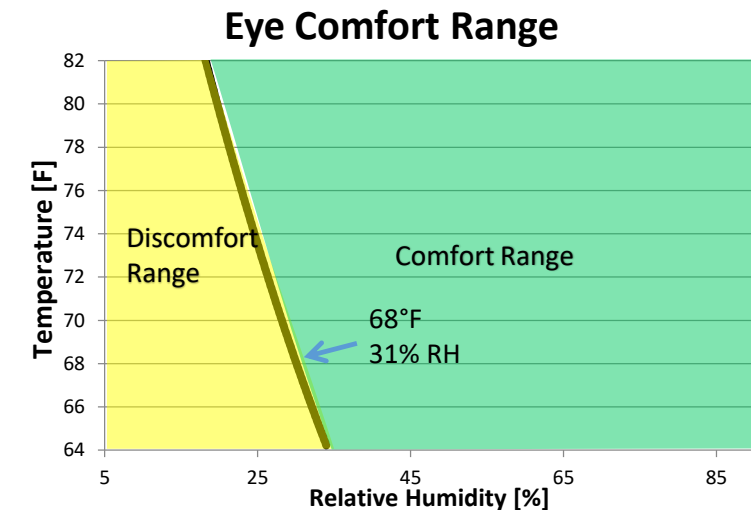
Human Body: Eyes

Our Eyes

- Protected by thin tear film
- Dry air causes increased desiccation
- Compounded by computer use
- Discomfort increases with time if dew point is below 26°F [1]

Typical Symptoms:

- Eye discomfort
- Redness
- Photosensitivity



¹J.E. Laviana, F.H. Rohles, Jr. and P.E. Bullock, *Humidity Comfort and Contact Lenses* (ASHRAE, 1988) 94(1), 3-11.

Human Body: Skin

Our Skin

- Skin provides protection and thermal regulation
- Thermal regulation via evaporative cooling
- Dry environments disrupt moisture balance
- Increased evaporation rates
- Below 30% RH skin becomes dry ^[1]



Typical Symptoms:

- Thermal discomfort
- Dryness of skin surface
- Inflammation / aggravation of skin conditions

1 Sunwoo Y, Physiological and Subjective Responses to Low Relative Humidity in Young and Elderly Men, (J Physio Anthropol, 2006 May), 25(3):229-38

Human Body: Throat

Our Throat

- Provides channel for air to enter lungs
- Conditions air we breathe
- Dry air draws requires more moisture



Typical Symptoms:

- Increased need to swallow
- Vocal chord irritation^[1]

US National Institute of Health recommends >30% RH and drinking water often

¹ National Institute on Deafness and Other Communication Disorders, *Taking Care of Your Voice*, <https://www.nidcd.nih.gov/health/taking-care-your-voice> (December 14, 2016)

Human Body: Nose / Immune System

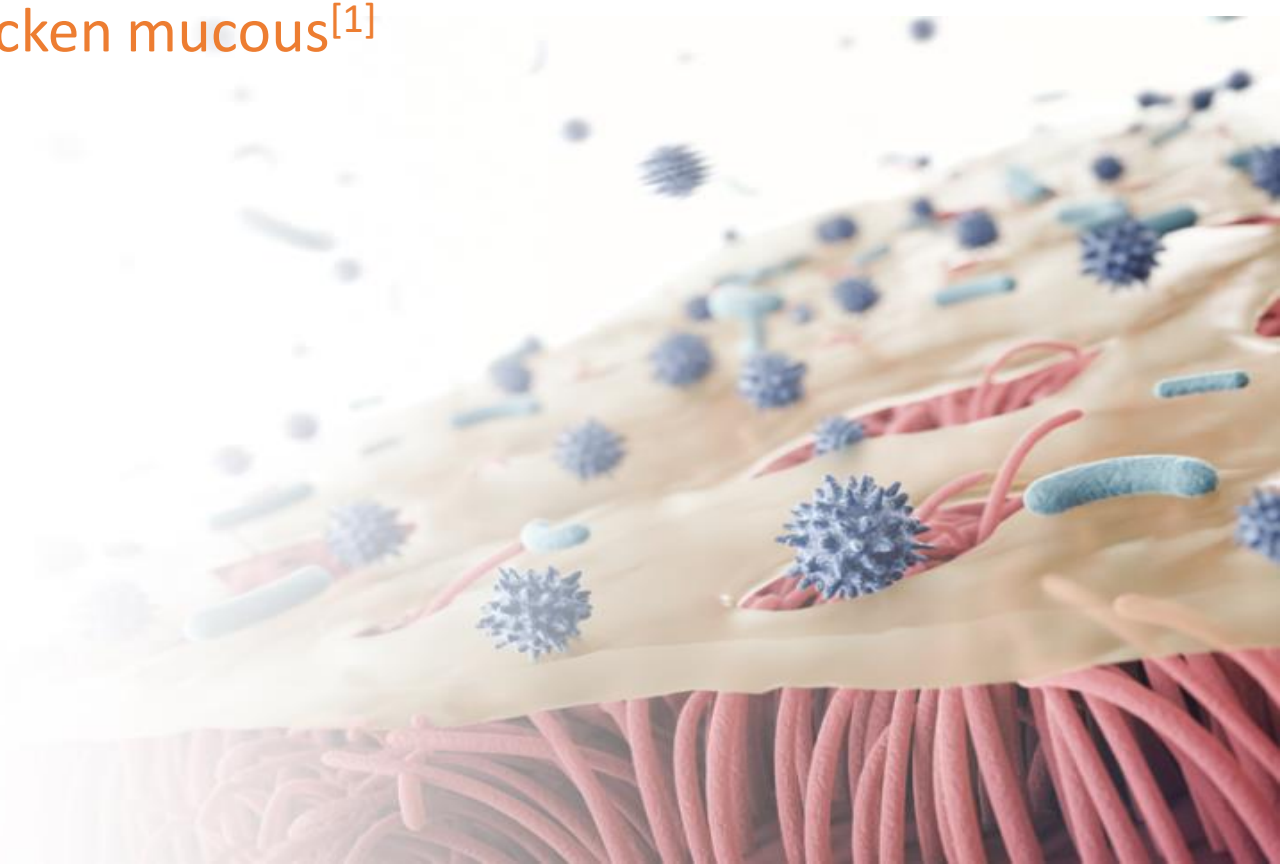
Our Nose / Immune System

- Mucous membrane and cilia filter we breathe
- Capture and drain infectious particles
- Dry environments desiccate and thicken mucous^[1]

Typical Symptoms:

- Reduced cilia motion
- Reduced ability for mucous to drain
- Increased risk of infection

¹J.P. Guggenbichler, R. Huster and S. Geiger, *Luftfeuchtigkeit und Immunabwehr*
Die Rolle der Schleimhaut und Auswirkungen auf die Klimatechnik (2007) Tab Technik AM, Vol. 38, No. 9



Human Body: Hydration

Our Body and Brain

- Rely on water for many processes
- Brain is ~85% water
- Dry environments increase water loss

Possible Symptoms

- Decreased cognitive function at 2% dehydrated
- Reduced short term memory
- Increased fatigue and moodiness



Dehydration affects brain structure and function in healthy adolescents. National Center for Biotechnology Information, U.S. National Library of Medicine, 2011. Kempton MJ, Ettinger U, Foster R, Williams SC, Calvert GA, Hampshire A, Zelaya FO, O'Gorman RL, McMorris T, Owen AM, Smith MS.

Humidity and Health Research

Humidity and Respiratory Infections

- Evidence of link between moisture and cold / flu transmission
- Clinical trials between 1963 and 1985 showed significant reduction of respiratory infections when mid-range humidity was maintained [1-5]



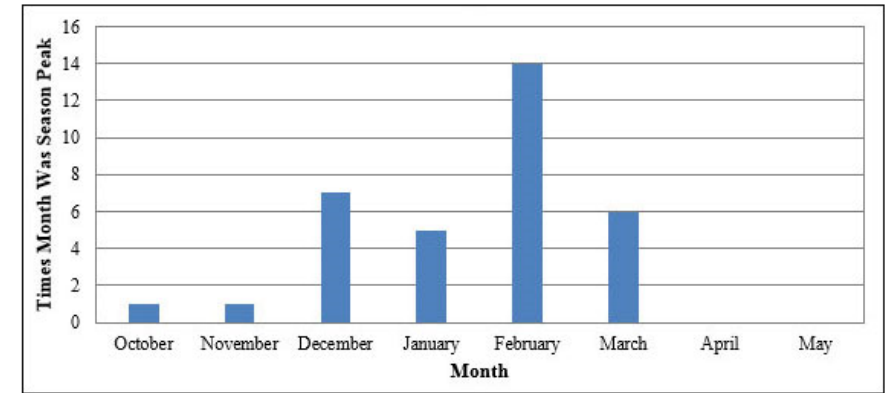
1. **Ritzel G**, Sozialmedizinische Erhebung zur Pathogenese und Prophylaxe von Erkältungskrankheiten, sog. «Kindergartenstudie» Zeitschrift für Präventivmedizin 1966, 11. 9-16
2. **Sale C**, Humidification to Reduce Respiratory Illnesses in Nursery School Children, Southern Medical Journal, July 1972, Vol 65
3. **Green G H**, Winter humidity and related absenteeism in Canadian hospitals, Digest of the 3rd. CMBES
4. **Green G H**, The effect of indoor relative humidity on absenteeism and colds in schools, ASHRAE Trans., Vol. 80, Part II
5. **Gelperin A**, Humidification and upper respiratory infection incidence, Heating, Piping and Air Conditioning, 45:3, 1973

Humidity and Influenza Seasonality

Influenza Peaks During Cold Months. Why? ^[1]

- More time indoors in proximity to others
- Drying of nasal mucous membrane weakens respiratory system
- Influenza virus is most stable at lower RH^[2]
- Exhaled aerosols float longer in lower humidity

Peak Month of Flu Activity
1982-1983 through 2015-2016



<https://www.cdc.gov/flu/about/season/flu-season.htm>

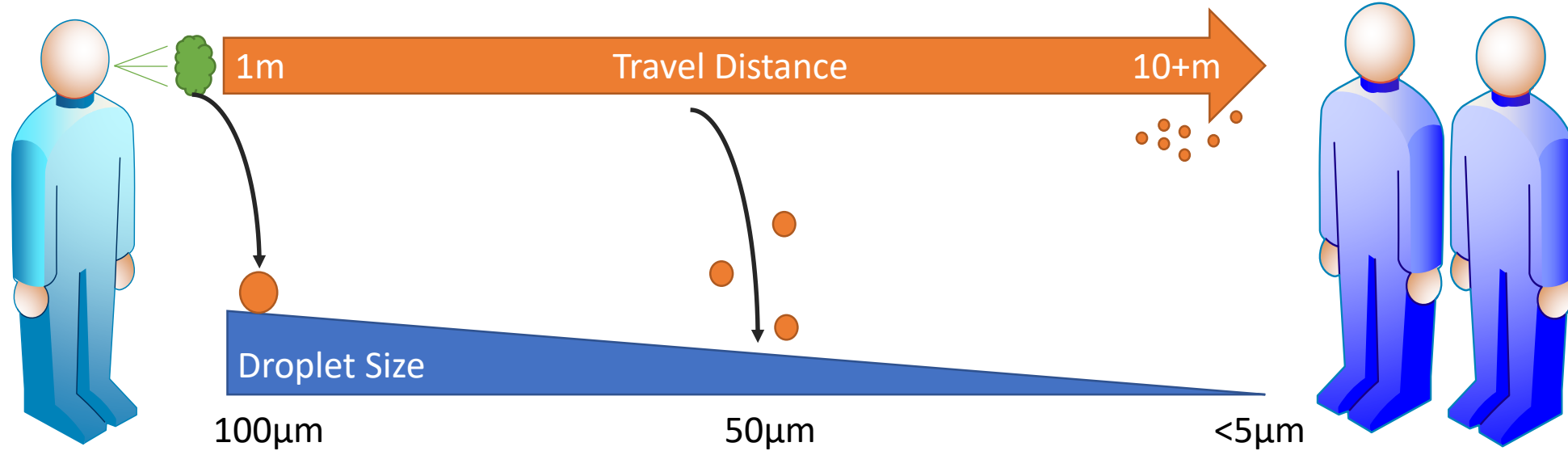
¹ Anice Lowen, et al, *Influenza Virus Transmission Is Dependent on Relative Humidity and Temperature* (October 19, 2007)

² J. Metz, et al, *Influenza and Humidity – Why a bit more damp may be good for you!* (June 2015)

Humidity and Exhaled Aerosols

Infectious payloads travel farther

- Particles lose mass quickly in dry environment
- Smaller, lighter particles travel farther
- Infectivity is retained^[1]



[1] Noti JD et. al, High Humidity Leads to Loss of Infections Influenza Virus from Simulated Coughs, PLoS ONE 8(2): e57485, 2013

Humidity and Healthcare Infections

Room Environment vs. Patient Infection Rates Research

- Microbiome study in a new hospital in the USA
- 240 single-occupancy inpatient rooms
- 52 ICU beds. 28 operating suites
- A three layer study over 13 months
- 10 monitored patient rooms
- 9 continuously measured parameters

(Room ACH, visitor traffic, outdoor air fractions, room pressure, temperature, absolute humidity, relative humidity, CO₂, air pressure, lux)

Results: 15% of Patients contracted a Healthcare Acquired Infection

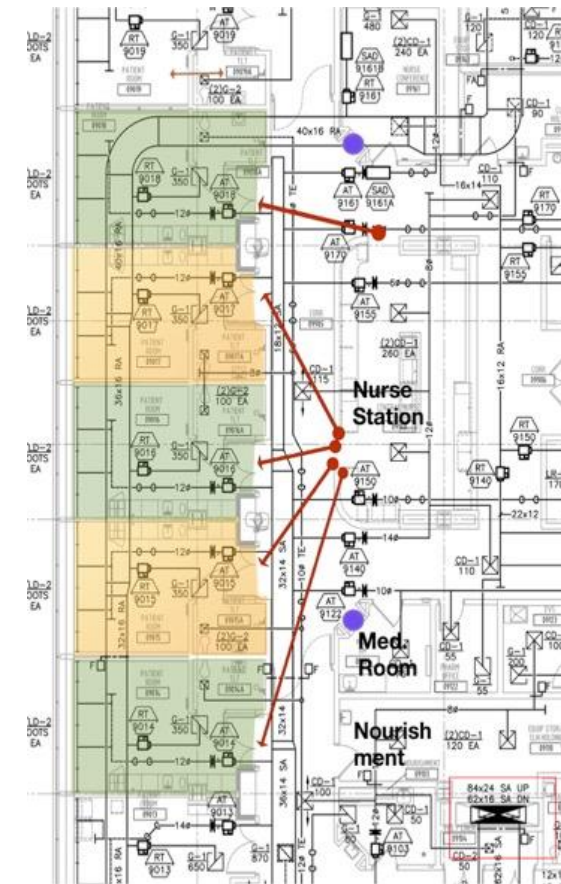
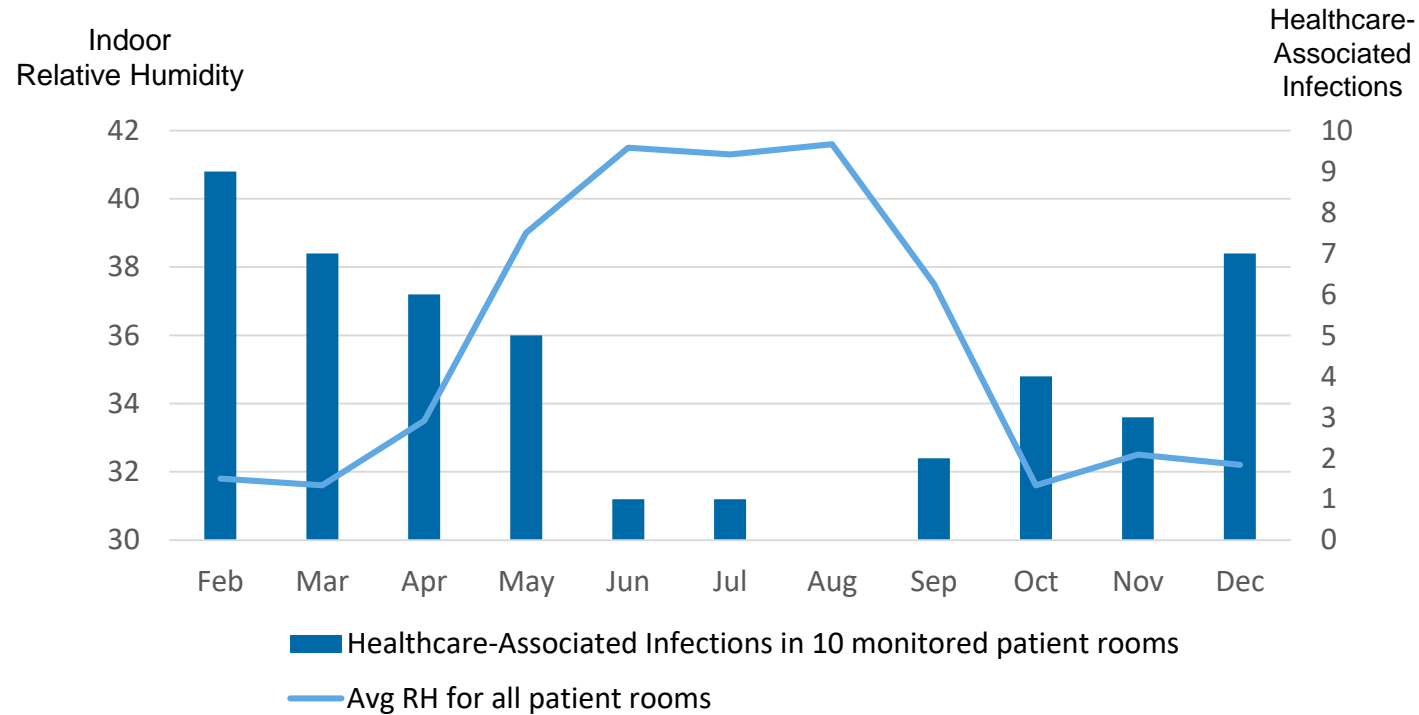


Image Courtesy: Dr. Stephanie Taylor

Humidity and Healthcare Infections



As relative humidity decreased infection rates increased

Confidence: ($t < 0.02$)

Humidity and Schools: Research

Hypothesis: “...raising absolute humidity above seasonal lows would impact influenza virus survival and transmission in a key source of influenza virus distribution, a community school.”

- Research builds upon NIOSH/CDC and microbiome research
- Focused on preschool classrooms
- Air and toys were sampled for influenza A
- Compared existing rooms with rooms where humidity was added

Humidity and Schools: Research

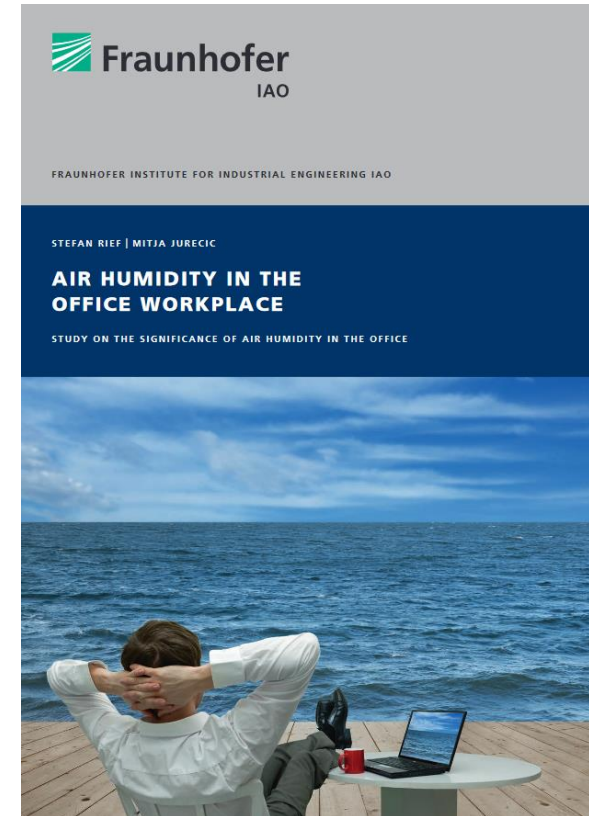
Results

- “There were 2.3 times as many ILI [influenza like illness] cases in the control rooms compared to the humidified rooms...”
- “... whether there is a causal relationship, and its direction between the number of cases and levels of influenza virus in the rooms is not known.”
- “Additional research is required, but this is the first prospective study suggesting that **exogenous humidification could serve as a scalable NPI [non-pharmaceutical intervention] for influenza or other viral outbreaks.**”

Humidity and Offices: Research

“Air humidity at the workplace can thus be assessed as a building block for increasing a person's well-being and for possibly reducing health risks.” [1]

- Reduced eye strain
- Reduced vocal strain
- Reduced allergy and asthma impact
- Increased employee performance
- Mental acuity
- Improved perceived comfort (“humidex”)

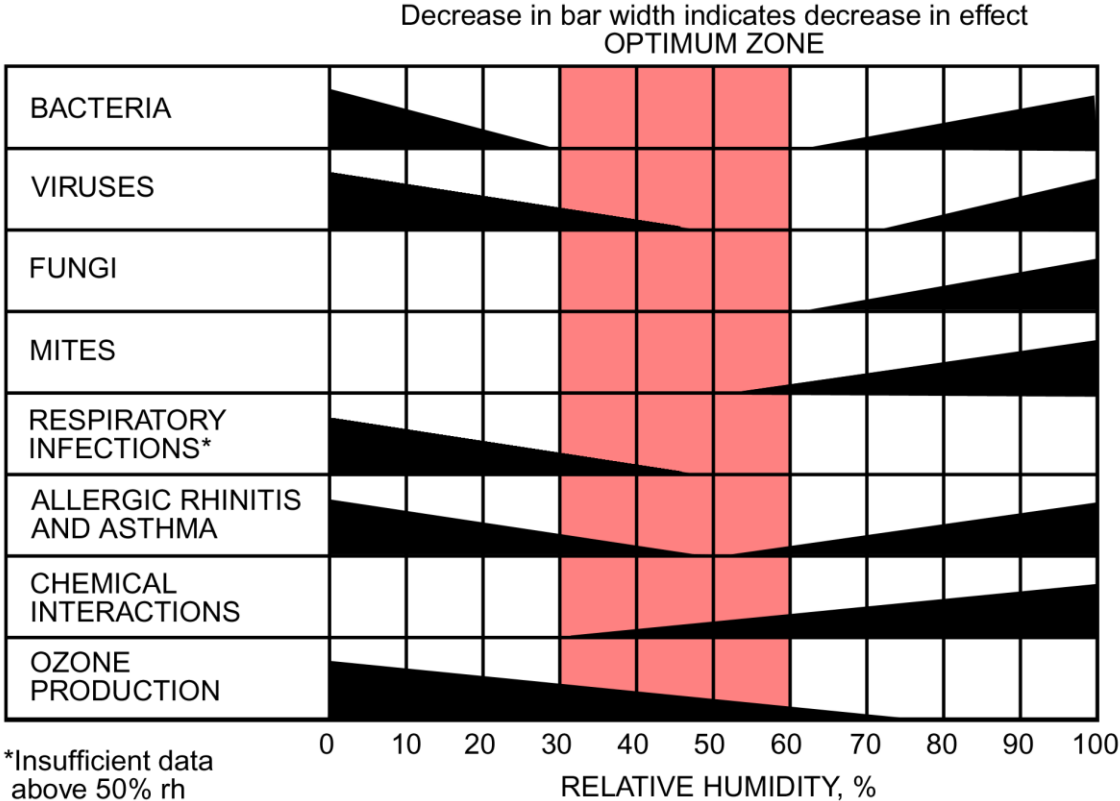


[1] Rief S and Juric M, Air Humidity in the Office Workplace, Fraunhofer IAO, 2014

Optimal Humidity

For People:

30 – 60% RH



©ASHRAE, www.ashrae.org. 2016 ASHRAE Handbook: HVAC Systems & Equipment, Ch 22.1
Adapted from Sterling et al. 1985

Applications: Humidity in Healthcare



- Conditions: 68-72°F (20–22°C), 40–60% RH
- Reduce hospital acquired infection rates
 - Improve patient outcome
 - Reduce lost bed and penalty cost
- Improved working environment
- ASHRAE 170-2017, Section 6.6.3
 - Now permits use of adiabatic fogging systems
 - Reduce cooling costs

Applications: Humidity in the Workplace



- Conditions: 68-72°F (20–22°C), 40–60% RH
- IBI Study 2012^[3]
 - Poor health costs US Economy \$576 Billion
 - 39% due to lost productivity
- Improve employee health and well being
 - Reduce spread of flu and respiratory illness
 - Reduce eye and vocal stress
 - Reduce skin dryness

[3] <https://ibiweb.org/research-resources/detail/poor-health-costs-u.s.-economy-576-billion-infographic>

Applications: Humidity at Home

- Conditions: 68-72°F (20-22°C), 30-60%* RH



Residential humidity is important for:

Health, comfort, preservation and energy savings

Today it is more common to encounter:

Tighter workspaces, lower plenum temperatures, radiant heating and varied housing construction

There are many options for residential humidity control including:

Atomizing, Evaporative, and Steam solutions

For more information see AHRI Guideline F

Selection, Installation and Servicing of Residential Humidifiers

*As appropriate for housing age and construction

Applications: Humidity in Education



- Conditions: 68-72°F (20–22°C), 40–60% RH
- Attendance Based Funding Methods
 - Funding proportional to daily attendance
 - Common in California, New York, Texas
- Reduce rates of flu and respiratory illness
 - Reduce absenteeism
 - Increase opportunities for learning

More resources

- Presentation online here: www.ahrinet.org/humidifiers

The screenshot shows the AHRI website interface. At the top left is the AHRI logo with the tagline "we make life better™". To the right are links for "Member Login", "Search Standards", and "Contact Us", along with a "Search Site" input field and a "Search" button. Below this is a navigation bar with links for "Certification", "Standards", "Contractors & Specifiers", "Homeowners", "Policy", "Resources", "News & Events", "About Us", and "Members". A "Search AHRI Certification Directory" dropdown menu is also visible. The main content area shows the breadcrumb "Contractors & Specifiers > HVACR Equipment/Components" and the title "HVACR Equipment/Components". Underneath is the sub-section "Humidifiers" with links for "Product Basics", "Installation Guidelines", "Maintenance Guidelines", and "Applicable Standards". A paragraph of text reads: "Did you know that in cold climates, when outdoor air is brought into a building and heated, the relative humidity can be as low as 10 percent — about the same as the Sahara Desert?". Below this text, a link "▶ AHR Expo Educational Presentations" is circled in green. On the right side of the page, there is a large blue water droplet graphic.

Questions?