The Importance of Humidity in Modern Buildings

AHRI Humidifiers Product Section

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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 adding humidity bring greater value to my client?
- How does humidity play a role in the industrial process?
- Can humidity affect quality of products?
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.
What is humidity?

Measured in “Absolute” or “Relative” terms

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

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

- **“E”** - enthalpy
- **Relative humidity**
- **t_{db}**
- **t_{wb}**
- **Specific volume**
- **Humidity ratio**
The psychrometric chart has the following lines and curves:

- **Isotherms** → Lines at constant temperature.

- **Isenthalpic lines** → Lines at constant enthalpy.

- **Isochores** → Lines at constant volume. Each isochore can correspond to a line at constant density $r$ (it is usually assumed that $r = 1.2 \text{ kg/m}^3 \Rightarrow \nu = 0.833 \text{ m}^3/\text{kg}$).

- **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.

- Humidifying
- Dehumidifying
- Cooling
- Heating
- Evaporative Cooling
- Heating & Humidifying
- Cooling & Dehumidifying
- Heating & Dehumidifying
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

- 100% RH
- 25% RH
- 120 gr (8g/kg)
- 30 gr (2g/kg)

Temperature

35°F (2°C) 72°F (22°C) 120°F (49°C)
Why Do Buildings Dry Out?

Outside air with low absolute humidity dries building

Outside Air
- 6°F (-14°C)
- 53% RH
  - 4 gr/lb (0.6 g/kg)

Sensible Heating

Inside Air
- 70°F (21°C)
- 4% RH
  - 4 gr/lb (0.6 g/kg)

Ventilation

In/Exfiltration
Humidification Applications
Humidity Solutions for Commerce and Industry

Humidity for Process

Humidity for Occupants
Applications: Preserves Hydroscopic 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

- **Hygroscopic 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
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

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

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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

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

**Typical Symptoms:**
- Reduced cilia motion
- Reduced ability for mucous to drain
- Increased risk of infection

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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

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 infects when mid-range humidity was maintained [1-5]

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

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 \[1\]

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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

[1] J. Reiman et al, Humidity as a non-pharmaceutical intervention for influenza A
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0204337
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.”

[1] J. Reiman et al, Humidity as a non-pharmaceutical intervention for influenza A
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0204337
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")

Optimal Humidity

For People:

30 – 60% RH
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](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](http://www.ahrinet.org/humidifiers)
Questions?