Heightened Awareness

The COVID-19 pandemic is changing the way we do almost everything. It is not the first virus to threaten vulnerable populations, and it certainly won’t be the last.

The World Health Organization is calling for a focus on non-pharmaceutical approaches.

Today’s presentation will dive into:

• The role of humidity in airborne transmission of viruses
• Employing humidification to help reduce the impact of pathogens, including SARS-CoV-2
• Practical solutions for raising the humidity levels to a minimum of 40% RH
Why be concerned about humidity levels of indoor environments?

**Persistence and distribution**
- Humidity influences the spread of airborne viruses.

**Infectivity**
- Humidity affects a patient’s immune response and the ability to fight off disease.
- Humidity impacts the severity of certain diseases, in particular respiratory infections.

**Viral activity**
- Humidity influences the life, or activity, of viruses.
- Humidity levels influence the ability to clean the clinical environment.

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Why It Is So Critical

- Protecting staff, employees and visitors
- Protecting patients or residents, many of whom are particularly vulnerable
- Managing cost
  - Conforming to the Joint Commission (JCAHO) Health Care Relative Humidity standards in order to avoid issues such as delays of operating room procedures, withheld Medicare or Medicaid payments, and potential loss of facility accreditation
ASHRAE Releasing New Information Frequently

- July 28, 2020 ASHRAE Newsletter
- Check ASHRAE website regularly, especially information from the Epidemic Task Force.
- Many other sources issuing valuable information.

Relative Humidity and Health

Optimum range for health, wellness and comfort: 40 - 60% RH

- Indoor environments are usually 20 - 30% RH, which is inadequate for protection
- Lower humidity increases survival for viruses that cause respiratory infections
- Lower humidity increases allergens that cause seasonal allergies and asthma
- The Sterling Study\(^1\) (right) was published in 1986
Other Relevant Studies

The notion that humidification levels reduce the transmission of viruses, bacteria, and allergens is not new. Studies have proven this over and over again:

**Yale**

Our study provides mechanistic insights for the seasonality of the influenza virus epidemics, whereby inhalation of dry air compromises the host’s ability to restrict influenza virus infection.

https://www.pnas.org/content/116/22/10905

**Mayo Clinic**

Increasing relative humidity (RH) to 40 to 60% in classrooms reduced the capacity of influenza to survive on surfaces or spread between classmates as aerosols.

https://www.biorxiv.org/content/10.1101/273870v2

ASHRAE Guidelines: Standard 170-2017

Current ASHRAE guidelines (20 - 60% RH) are expected to change with higher humidity levels being adopted within healthcare settings.

- ASHRAE Std 170 has higher RH levels in certain clinical settings such as:
  - Intensive Care Units (30 - 60% RH)
  - Burn Units (40 - 60% RH)
- However, Table 7.1 recommends many spaces well below 40% RH
### Other countries maintain higher standards

<table>
<thead>
<tr>
<th>Country</th>
<th>RH Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>20 - 60 % RH</td>
</tr>
<tr>
<td>CHINA</td>
<td>30 - 60 % RH</td>
</tr>
<tr>
<td>UK</td>
<td>35 - 60 % RH</td>
</tr>
<tr>
<td>JAPAN</td>
<td>40 - 65 % RH</td>
</tr>
</tbody>
</table>

### Understanding Airborne Viruses: Droplet Size

**Stages of Infectious Droplets & Droplet Nuclei**

1. **Large droplets-20μ+**
   - Viruses
   - Mucus/water coated
   - Viruses aerosolized and they cannot evaporate fast enough and quickly fall to the ground.

2. **Small droplets/aerosols-10-20μ**
   - Mucus/water coating
   - These droplets will travel 3-8 feet before falling to the ground.

3. **Droplet Nuclei-<10μ**
   - Mucus/water coating has mostly evaporated leaving the virus with protein & salts.
   - This is a Droplet Nuclei
   - Droplet Nuclei are so micron-sopic that they can float in the air indefinitely.

Researchers have captured pathogen bearing aerosols travelling up to **25 feet** from a simple sneeze.

Factors influencing travel and evaporation include temperature and relative humidity.

https://jamanetwork.com/journals/jama/article-abstract/2763852
Understanding Airborne Viruses: Computer Modelling

Researchers modelled the airborne movement of aerosol particles smaller than 20 micrometers.

- For a dry cough, which is a typical symptom of the current coronavirus, the particle size is typically less than 15 micrometers.
- Extremely small particles of this size do not sink on the floor, instead they move along in the air currents or remain floating in the same place.
- Studies of influenza A have confirmed that the influenza A virus can be found in the smallest particles, which measure less than 5 micrometers.

[Link to news article about researchers modelling the spread of the coronavirus and emphasising the importance of avoiding busy places]

Humidity levels and Infectivity of Influenza

High humidity reduces the infectivity of influenza

- Total Aerosol Fractions
- 1-4 µM Fraction
- >4 µM Fraction
- <1 µM Fraction

[Links to journal articles discussing the effects of humidity on influenza infectivity]

Aerosol Behavior: Impact on Infectivity

A µm is a micron or 1/1,000,000 of a meter. The smallest particle you can see is 30 µm.

Humidity levels and Human Immuno-response

Self-Clearance Mechanism of the Lung

- Environmental particles and pathogens are carried into the lungs as we inhale air.
- Nature developed a powerful mechanism to self-clean the airways: their cellular linings operate as conveyor belts.
- Inhaled particles collide with the airway walls where they get stuck on slimy surfaces.
- The prevalent location where inhaled particles get deposited along the airways depends on the particle size.
- The particle-enriched mucus, including virus particles, is transported towards the mouth through synchronized circular movements of cilia.

Adapted from Blusen/Wikipedia/CC BY 3.0
Hospital Acquired Infections (HAIs)

Annually, approximately 2 million patients suffer with hospital-acquired infections (HAIs) in the USA, and nearly 90,000 are estimated to die.

The overall direct cost of HAIs to hospitals ranges from **$28 billion to $45 billion**.

Mean hospital cost per infection (US)²

- Central-line-associated bloodstream infection: $36,441
- Surgical-site infection: $25,546
- Ventilator-associated pneumonia: $9,966

Huge economic cost with an annual influenza epidemic³

- $10.4 billion a year in direct medical expenses
- $16.3 billion in lost earnings annually
- $87 billion a year total economic burden

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**Study Results: Indoor Relative Humidity vs. Patient HAIs**

Average RH for all Patient Rooms

Source: Colonization and Succession of Hospital-Associated Microbiota, In Press 2016
Simon Lax, Daniel Smith, Naseer Sangwan, Kim Handley, Peter Larsen, Miles Richardson, Stephanie Taylor, Emily Landon, John Alverdy, Jeffrey Siegel, Brent Stephens, Rob Knight, Jack A Gilbert

www.ahrinet.org/Agg_Content/ahr/files/Humidity_Occupants_Presentation.pdf
ASHRAE Guidelines: Epidemic Task Force

On the recommendation of the ASHRAE Epidemic Task Force, ASHRAE leadership has approved the following two statements regarding transmission of SARS-CoV-2 and the operation of HVAC systems during the COVID-19 pandemic:

Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures.

Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air. Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. In general, disabling of heating, ventilating, and air-conditioning systems is not a recommended measure to reduce the transmission of the virus.

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

Not Just Hospitals! Offices, Schools, Homes

• Results of study apply more broadly
  – Infectious organisms found everywhere
  – Controlling humidity is essential

• Healthy employees pay dividends
  – Fewer sick days
  – Reduced healthcare costs
  – Increased productivity

• Costs and incentives
  – Hospitals penalized monetarily by HAI rates
  – Schools incentives for performance
  – What does illness cost each organization?
Hospital Building Technologies

- Raise humidity to 45% +
- Increase air changes to 12 per hour
- In-duct UV
- Upper room UV
- Toilet seat lowered
- Exhaust behind & below toilet
- MERV 13 + URV 13
- UV lights
- MERV 17
- HEPA (best)

FLU SEASON MITIGATED!

Practical Solutions to Achieve 40% RH

What Really Happens When the Set-Point is Raised
Technical considerations of increasing space RH to 40%

**Existing Equipment**

- What can be done with existing equipment?
- Humidifiers are typically designed for a maximum humidification design day...how much of the year can we get from original design to achieve 40% RH?
- Review historical humidification demand to determine potential humidification levels.

### Percent of hours at 40% RH when originally designed for:

- 20% RH = 48%
- 25% RH = 70%
- 30% RH = 81%
- 35% RH = 93%

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**Strategies when additional load is needed**

- Add capacity with additional steam generators
- Can it be added in the air-handler?
  - Good for base loads of large spaces
- Is it possible to use point-of-use humidifiers in ductwork or space?
  - Boost humidity to specific zones
Solutions

Keeping indoor humidity levels at 40% - 60% RH is a safe, easy and efficient way to reduce the spread of viruses that cause respiratory illnesses in our buildings and protect occupant health.

- Some humidification systems can be quickly installed on a wall and start adding moisture to rooms right away.

- Larger humidification systems can be incorporated into a facility’s HVAC system, in the mechanical room or on the roof in weatherproof enclosures, and can keep an entire building humidified.

Technical considerations of increasing space RH to 40%

Adding Capacity with Multi-Tank Controls

- Multi-tank function accommodates control of multiple steam generators

- Steam generators in the same system can vary by energy source and capacity

- Master controller receives control signal and controls steam output of up to 16 units based on Priority Groups
Technical considerations of increasing space RH to 40%

Non-wetting distance
Non-wetting distance increases with higher downstream moisture levels

Non-wetting distance for a 70°F space with varying RH levels
10,000 CFM / 30% OA application

20%RH 30%RH 40%RH
6 in 10 in 18 in
25%RH 30%RH
7 in 14 in

Existing Equipment

• Is there an opportunity to reduce the outside air volume to get to 40% RH?
  – Most likely possible on economizer applications
• If non-wetting distance becomes too long can the supply temperature be raised?

<table>
<thead>
<tr>
<th>Outside dry bulb temperature (°F)</th>
<th>Outside air intake rate</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5</td>
<td>24.4</td>
<td>64.81</td>
</tr>
<tr>
<td>15</td>
<td>27.3</td>
<td>71.39</td>
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<tr>
<td>20</td>
<td>30</td>
<td>77.21</td>
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<td>75</td>
<td>156.88</td>
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<tr>
<td>55</td>
<td>100</td>
<td>195.54</td>
</tr>
</tbody>
</table>
Technical considerations of increasing space RH to 40%

**Strategies when additional load is needed**
Change dispersion tube orifice size and/or add insulated dispersion tubes

![Dispersion Tubes](image1)

**Dispersion Tube Heat Loss**

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**Humidification load and power usage**
Power usage increases with larger humidification loads

![Humidification Load Chart](image2)

**Humidification load and power usage for a 70F space with varying RH levels – 10,000 CFM / 30% OA application**

- **Load (pph)**
- **Power (kW)**

### Load and Power at Different RH Levels:
- **20% RH**: Load 31.9 ppd, Power 10.6 kW
- **25% RH**: Load 42.3 ppd, Power 14.1 kW
- **30% RH**: Load 52.7 ppd, Power 17.6 kW
- **35% RH**: Load 63 ppd, Power 21 kW
- **40% RH**: Load 73.4 ppd, Power 24.5 kW
Technical considerations of increasing space RH to 40%

Pressurized Steam Humidification Systems

On pressurized steam dispersion panels and STS (Steam-to-Steam) units - increase steam valve size, CV or steam pressure

<table>
<thead>
<tr>
<th></th>
<th>5 psi (34 kPa)</th>
<th>10 psi (69 kPa)</th>
<th>13 psi (90 kPa)</th>
<th>15 psi (100 kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lbs/hr</td>
<td>kg/h</td>
<td>lbs/hr</td>
<td>kg/h</td>
</tr>
<tr>
<td>25C</td>
<td>20</td>
<td>9</td>
<td>70</td>
<td>32</td>
</tr>
<tr>
<td>50C</td>
<td>50</td>
<td>23</td>
<td>150</td>
<td>68</td>
</tr>
<tr>
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<tr>
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</tr>
<tr>
<td>800C</td>
<td>650</td>
<td>295</td>
<td>1275</td>
<td>578</td>
</tr>
</tbody>
</table>

Preventing Condensation

- Raising the space RH can lead to a dew point temperature higher than the inside surface temperature of exterior windows causing condensation to form.

- Utilize a **Temperature Compensation Transmitter** to lower the RH set-point and keep the space dew point temperature below the interior surface temperature of exterior windows.
Technical considerations of increasing space RH to 40%

Getting equipment back up and running

• Determine if any replacement parts are needed
• Remove scale from tank or replace electrode cylinder
• Check if there is a software update

Technical considerations of increasing space RH to 40%

Getting equipment back up and running

• Check interconnecting hose or tubing to ensure no low spots and that proper condensate management can occur
• Inspect dispersion panel to make sure all tubes are functional
Technical considerations of increasing space RH to 40%

Getting equipment back up and running

Consider adding water treatment equipment to minimize downtime and extend humidifier life

- Reverse Osmosis Systems
- Water Softeners

Summary

- Approximately 1 kW required for every 3 Lbs/Hr of increased humidification output
- Check that the dispersion panel and interconnecting hose or piping can handle increased load – may need partial or complete replacement
- Account for longer non-wetting distance, including high-limit sensor location
- Consider upgrading to best capacity modulation, high-accuracy humidity sensors and modulating high-limit safeties that will provide better performance and control.
- Add temperature compensation transmitter to prevent condensation on windows
The Bottom Line

Humidification is **common sense science** when it comes to protecting staff, patients, and residents.

You can make this change **immediately** and **easily**.

For more resources, go to [www.dristeem.com/humidification-for-virus-reduction](http://www.dristeem.com/humidification-for-virus-reduction)

Next Steps

**Contact your local DriSteem representative for more information**

R. L. Deppmann  
46575 Magellan Drive  
Novi, Michigan 48377  
Phone: (800) 589-6120  
www.Deppmann.com

(or go to www.dristeem.com and click **Find a Rep** at the top)
Sources

