Humidity Control in Commercial Buildings

... Designing for Absolute Humidity Control

Presentation for:
Chattanooga, TN ASHRAE Chapter

R. Mark Nunnelly, P.E., CxA
Nunnelly & Associates, Inc.
Commissioning & Humidity Control Consulting
Birmingham, AL

mnunnelly@nunnellyengineering.com
www.nunnellyengineering.com
Why is uncontrolled moisture a concern? 

.... it is a major IAQ concern!

HEADLINES

- Legal Implications of Mold Contamination of HVAC Systems
- Bad air breeds ailments in homes, schools, offices
- Mold in Schools: a health alert
- Mold takes over school, causing nightmare
- GOOD SCHOOL, BAD AIR – A humid brew of mold and mildew is filling S.C. classroom with coughs
- Mold sensitization is common amongst patients with severe asthma requiring multiple hospital admissions
- Two New Orleans Hospitals Beyond Help ... The buildings have unsafe air to breathe, pervasive mold growing ...
- The Hidden Risks of Green Buildings: Why Moisture & Mold Problems are Likely
- Holding the Line: Controlling Unwanted Moisture in Historic Buildings
How does moisture get into buildings?

- **Infiltration** ... as a vapor or a liquid (requires attention to the building envelope)

- **Ventilation Air** ... greater requirements for fresh air within buildings (the more air ... the more moisture)

- **Internal Moisture Gain** ... from people, processes, or spills.
Our primary focus today will be that of the Heating, Ventilating and Air-conditioning System, and not the Building Envelope Integrity.
Why is Humidity Control important?

- Human Comfort
- Indoor Air Quality (e.g., Molds, Dust mites)
- Integrity or sustainability of the building and its fixtures and furnishings
Who Needs Dehumidification?
They Do!...for comfort and IAQ
Control Humidity to Preserve Investments and Furnishings
... and they do ... for comfort, health, furnishings and sustainability of the building!
... and they do!
School: No Absolute Control of Moisture
Why do we “air-condition” our buildings?
Why do we “air-condition” our buildings?

- Control Temperature
  - Comfort
  - Stability of materials, archives, art, books, etc.
  - Industrial process requirements
Why do we “air-condition” our buildings?

- Control Temperature
- Control Humidity/Moisture
  - Comfort
  - Limit microbial growth
  - Limit potential threat of viruses, bacteria, etc.
  - Stability of art, books, etc.
  - Maintain longevity of building materials
  - Industrial process requirements
Why do we “air-condition” our buildings?

- Control Temperature
- Control Humidity/Moisture
- Control Air Movement
  - Comfort (airflow velocity)
  - Containment/Spread of air contaminants, odors, etc.
  - Positive/Negative Air pressure requirements
  - Maintain Envelope integrity (i.e., limit mold growth potential)
Why do we “air-condition” our buildings?

- Control Temperature
- Control Humidity/Moisture
- Control Air Movement
- Control Air Quality
  - Filtration
  - Environmental Air Quality includes all of the above
Why do we “air-condition” our buildings?

- Control Temperature
- Control Humidity/Moisture
- Control Air Movement
- Control Air Quality

CONTROL the environment!
Why is it so “hard” to control HUMIDITY?

- Lack of understanding of PSYCHROMETRICS
- Unaware of published ASHRAE Weather data (since 1997 *Fundamentals Handbook*)
- Installing inappropriate equipment for the task (selection type and/or capacity)
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Psychrometrics
PSYCHROMETRICS

**Definition:** Is the study of the physical and thermodynamic properties of air and water vapor mixtures.

All the air we breathe contains some amount of *moisture.*
Psychrometric Chart
Who remembers World Book Encyclopedias?
My favorite volume – Volume H
(Human Body)

Study the Body one system at a time
Systems of the Human Body

- Circulatory/Cardiovascular
- Digestive
- Endocrine
- Lymphatic
- Respiratory
- Uninary
- Muscular
- Nervous
- Skeletal
- Reproductive
Systems of the Psychrometric Chart

*Drybulb Temperature*

*Wetbulb Temperature*

*Dewpoint Temperature*

*Enthalpy*

*Relative Humidity*

*Humidity Ratio (Specific Humidity)*

*Sensible Heat Ratio*

*Vapor Pressure*

*Specific Volume*
Dry Bulb Temperature

The temperature of air as measured by a thermometer with a dry sensing bulb.
Wet Bulb Temperature

- The temperature at which water will evaporate into the air sample.
- Physically... the temperature of air when measured by a thermometer with a wetted wick over the sensing bulb.
Relative Humidity

- The amount of water vapor in the air, compared to its maximum capacity at that dry bulb temperature
- \textit{Relative} measurement... not \textit{absolute}
How does the relative humidity affect the comfort?
Why is Understanding “Relative Humidity” Beneficial?

Many charts, tables and standards use “Relative Humidity” as a reference or guideline.
## INDOOR AIR QUALITY

Effect of room humidity on selected human health parameters

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<th>Decrease in Bar Width</th>
<th>OPTIMUM ZONE</th>
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<tr>
<td>Indicates Decrease in Effect</td>
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<td>Bacteria</td>
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<td>Allergic Rhinitis and Asthma</td>
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<td>Chemical Interactions</td>
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<td>Ozone Production</td>
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</table>

Indirect Health Effects of Relative Humidity in Indoor Environments

(AV Arundel, EM Sterling, JH Biggin and TD Sterling - 1986)

19°C to 27°C (i.e., 66.2°F to 80.6°F)
Fig. 5 ASHRAE Summer and Winter Comfort Zones
[Acceptable ranges of operative temperature and humidity with air speed ≤ 40 fpm for people wearing 1.0 and 0.5 clo clothing during primarily sedentary activity (≤1.1 met).]

ASHRAE Standard 55, which specifies conditions or comfort zones where 80% of sedentary or slightly active persons find the environment thermally acceptable.
## Space Design Conditions for the OR

<table>
<thead>
<tr>
<th>Function Space</th>
<th>Operating Room (100% Outside Air System)</th>
<th>Operating Room (Recirculating Air System)</th>
<th>Operating Room Surgical Cystoscopic Rooms</th>
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<tr>
<td><strong>Minimum Air Changes of Outdoor Air / Hour</strong></td>
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<td><strong>Design Temperature, °F</strong></td>
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<td>AIA Guideline</td>
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<td>68-73</td>
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</table>

* No Value Given
To “ABSOLUTELY” control humidity within buildings, we must understand *absolute* humidity, not just *relative* humidity.
Absolute Humidity: Humidity Ratio

- The weight of water vapor divided by the weight of the dry air ($\frac{lb_w}{lb_a}$) - an *absolute* measurement

- $\frac{lb_w}{lb_a} \times 7000 = \text{grains of water per lb of air}$
Dew Point

- The temperature at which the moisture contained in the air will begin to condense (i.e., the temperature at which the air sample would be 100% RH).
- Another *absolute* measurement of moisture
“Raining” in the Operating Rooms!
Why is it important to understand “dewpoint”? 
What happens when the dewpoint temperature of the air is greater than the surrounding surfaces’ temperature?
In Chattanooga, TN outdoor air being sucked into the building cavities is 83°F, 140 gr/lb. How cold does the inside wall surface have to be to produce condensation?

In other words - What is the dewpoint of air at 83°F, 140 gr/lb? 76.7°F dewpoint.
83Fdb / 140 gr/#
76.7Fdp

Point of condensation
without vapor retarder

73Fdb

73 Fdb / 50% rh
Vinyl wall-coverings on an outside wall in the South is a No-No!
Consider the balloon of 1 Ft³ volume at ambient temperature containing an absolute amount of water of 3.75 gallons. What happens when the balloon is either heated or cooled? What is the new “relative” volume of water? What is new “absolute” volume of water?
Molds and mildew are fungi that grow on the surfaces of objects, in pores, and in deteriorated materials. They can cause discoloration and odor problems, deteriorate building materials, and lead to allergic reactions in susceptible individuals, and other health problems.

The following conditions are necessary for mold growth to occur on surfaces:

- Temperature between 40°F and 120°F
- Nutrient base
  (most surfaces contain nutrients)
- Moisture
- Mold spores
Enthalpy

- Total Amount of Energy in the air
- BTU/# Dry Air

28.1 Btu/#
Heat Load Formulas

- **Total Load (i.e., Sensible + Latent)**
  
  \[ Q_T, \text{ Btu/hr} = 4.5 \times (\text{Enthalpy Difference}) \times \text{cfm} \]

- **Sensible Load**
  
  \[ Q_S, \text{ Btu/hr} = 1.08 \times (\text{Temperature Difference}) \times \text{cfm} \]

- **Latent Load**
  
  \[ Q_L, \text{ Btu/hr} = 0.68 \times (\text{Humidity Ratio Difference}) \times \text{cfm} \]

\[ Q_T = Q_S + Q_L \]
Moisture Removal Formula

- **Total Moisture Removed**

  \[
  \text{Pounds Moisture/hr} = 4.5 \times (\Delta \text{Humidity Ratio}) \times \text{cfm} / 7000
  \]

Example:
- Air Handler with airflow of 4,000 CFM through coil
- Mixed Air Condition of 80Fdb/67Fwb (i.e., HR=78.6 gr/#)
- Leaving Air Condition of 55Fdb/54Fwb (i.e., HR=60.7 gr/#)

  \[
  \text{Total Moisture Removed} = 4.5 \times (17.9) \times 4000 / 7000
  \]

  \[
  \text{Total Moisture Removed} = 46.03 \text{ # Moisture/Hr}
  \]

  \[
  = 5.53 \text{ Gallons Moisture / Hr}
  \]
A measure of how high the water vapor can lift a column of mercury due to its pressure.
Vapor Pressure continued ...

Moisture travels from the HIGHER Vapor Pressure to the LOWER Vapor Pressure. The difference in Vapor Pressure is the driving force behind moving water vapor.
Applied Psychrometrics

- What is the Vapor Pressure of the air inside a building at the conditions of 75°F drybulb and 50% RH? 0.438”hg
- What is the Vapor Pressure of the air outside a building at the conditions of 82°F drybulb and 77°F wetbulb? 0.883”hg
- Vapor Pressure Differential of 0.445”hg (x 13.596 = 6.052”wg)
Influence of Vapor Pressure

(0.883 - 0.438) \times 13.596 = 6.052” wg

Bernoulli’s Equation: Dynamic Velocity Rate =

4005 \sqrt{6.052} = 9,852.6 FPM = 112 MPH
2

ASHRAE Weather
Conditions
Outside Air Design Conditions

Understanding ASHRAE Weather Tables
### 2017 ASHRAE Fundamentals Handbook – Climatic Conditions

#### Climates and Design Conditions

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean Temperature</th>
<th>Standard Deviation</th>
<th>n-year Period of Extreme Temperatures</th>
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#### Monthly Climate Design Conditions

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean Design Dry Bulb Temperature</th>
<th>Mean Winter Window Temperature</th>
<th>Mean Design Wet Bulb Temperature</th>
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#### Temperature and Humidity Design Conditions

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean Daily Temperature Range</th>
<th>Mean Design and Winter Window Temperature</th>
<th>Mean Design Wet Bulb Temperature</th>
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#### Annual Heating and Cooling Design Conditions

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<thead>
<tr>
<th>Month</th>
<th>Heating Degree Days</th>
<th>Cooling Degree Days</th>
<th>Heating Degree Days at 65°F</th>
<th>Cooling Degree Days at 75°F</th>
<th>Heating Degree Days at 70°F</th>
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### Annual Cooling, Dehumidification, and Enthalpy Design Conditions

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<th>Hottest Month</th>
<th>Hottest Month DB Range</th>
<th>Cooling DB/MCWB</th>
<th>Evaporation WB/MCDB</th>
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<td>129.3</td>
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</table>
Understanding ASHRAE Weather Tables

What do the 0.4%, 1.0% and 2.0% occurrence values mean?

- Basically, this will tell you the number of hours, based on historical data for the selected city, that the peak Drybulb, Wetbulb, Dewpoint temperatures and/or Enthalpy that these peaks could be exceeded when using this climate data for your designs.

- For example, understanding that a year has 8,760 hours, choosing the 0.4% occurrence climate data when calculating your cooling loads means that based on historical data, there could be approximately 35 hours in the year where the temperature within the building could be slightly warmer than the setpoint for which the cooling equipment was designed.

- In like manner, choosing the 1.0% occurrence value means that there could be 87.6 hours per year when setpoints are exceeded. (2.0% values = 175.2 hours/year)

- Generally, the building types with stricter, tighter tolerances would be designed using the 0.4% values (e.g., clean rooms, surgical suites, museums, libraries, archives, etc.) Less critical building types could use the 1.0% and even the 2.0% values (e.g., offices, schools, supermarkets, etc.)
The 0.4, 1.0, and 2.0% dry-bulb temperatures and mean coincident wet-bulb temperatures often represent conditions on hot, mostly sunny days. These are often used in sizing cooling equipment such as chillers or air-conditioning units.
The extreme maximum wet-bulb temperature provides the highest wet-bulb temperature observed over the entire period of record and is the most extreme condition observed during the data record for evaporative processes such as cooling towers.
Understanding ASHRAE Weather Tables

Mean Windspeed & Direction Coincident with 0.4% Drybulb

(MCWS/PCWD to 0.4% DB)

The mean wind speed and direction coincident with the 0.4% design dry-bulb temperature is used for estimating peak loads accounting for infiltration.
Understanding ASHRAE Weather Tables

Dewpoint / Mean Coincident Drybulb & Humidity Ratio

(DP/MCDB & HR)

Design conditions based on dew-point temperatures are directly related to extremes of humidity ratio, which represent peak moisture loads from the weather. Extreme dew-point conditions may occur on days with moderate dry-bulb temperatures, resulting in high relative humidity. These values are especially useful for humidity control applications, such as desiccant cooling and dehumidification, cooling-based dehumidification, and outdoor-air ventilation systems. The values are also used as a check point when analyzing the behavior of cooling systems at part-load conditions, particularly when such systems are used for humidity control as a secondary function. Humidity ratio values are calculated from the corresponding dew-point temperature and the standard pressure at the location’s elevation.
Typical Ambient Conditions

Dry Bulb and Grains

- Degrees
- Grains

Hours of the Day

Dry Bulb

Grains
Of Interest to Cooling Designers

- Highest Enthalpy occurs at peak dewpoint, NOT peak dry-bulb
  - Chattanooga: 39.2 Btu/# at peak Dewpoint vs. 37.7 Btu/# at Drybulb peak (at 1% Occurrence)
- Peak Dewpoint allows “part-load” checkpoint for cooling systems
  - Will the system work properly at “part-load”?
- Outside air pre-treatment systems can be designed for true peak load (moisture peak)
- Evaporative equipment (i.e., Cooling Towers) can be better sized
  - No need to guess what Drybulb occurs at peak Wetbulb
Of Interest to Dehumidification Designers

- Finally! Peak humidity data that the client can believe
  - Comes from ASHRAE research - not proprietary sources
  - First published in the 1997 ASHRAE Handbook - not just a one-time technical paper
- Finally! Drybulb temperature coincident to peak moisture
- Peak moisture is also an excellent cross-check for behavior of cooling systems where dehumidification is “non-critical”
  - Schools, offices, theaters, restaurants
### Climatic Conditions

#### Monthly Climatic Design Conditions

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean Dry-Bulb Temperature</th>
<th>Wet-Bulb Temperature</th>
<th>Indoor Relative Humidity</th>
<th>Outdoor Relative Humidity</th>
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</thead>
<tbody>
<tr>
<td>Jan</td>
<td>68.4°F</td>
<td>78.0°F</td>
<td>55%</td>
<td>65%</td>
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<tr>
<td>Feb</td>
<td>72.4°F</td>
<td>78.0°F</td>
<td>55%</td>
<td>65%</td>
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<tr>
<td>Mar</td>
<td>71.5°F</td>
<td>78.0°F</td>
<td>55%</td>
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</tr>
<tr>
<td>Apr</td>
<td>71.4°F</td>
<td>78.0°F</td>
<td>55%</td>
<td>65%</td>
</tr>
<tr>
<td>May</td>
<td>71.1°F</td>
<td>78.0°F</td>
<td>55%</td>
<td>65%</td>
</tr>
<tr>
<td>Jun</td>
<td>71.4°F</td>
<td>79.3°F</td>
<td>55%</td>
<td>65%</td>
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<tr>
<td>Jul</td>
<td>71.7°F</td>
<td>80.1°F</td>
<td>55%</td>
<td>65%</td>
</tr>
<tr>
<td>Aug</td>
<td>72.2°F</td>
<td>81.1°F</td>
<td>55%</td>
<td>65%</td>
</tr>
<tr>
<td>Sep</td>
<td>71.5°F</td>
<td>79.4°F</td>
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<tr>
<td>Oct</td>
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<td>77.5°F</td>
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<td>65%</td>
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<td>Nov</td>
<td>66.9°F</td>
<td>75.7°F</td>
<td>55%</td>
<td>65%</td>
</tr>
<tr>
<td>Dec</td>
<td>66.3°F</td>
<td>75.7°F</td>
<td>55%</td>
<td>65%</td>
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#### Extreme Annual Temperatures

<table>
<thead>
<tr>
<th>Extreme Annual Temperature</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Min</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>71°F</td>
<td>71°F</td>
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</table>

#### Daily Temperature Ranges

<table>
<thead>
<tr>
<th>Mean Daily Temperature Range</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Min</th>
<th>Max</th>
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<tr>
<td>21.8°F</td>
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</table>

#### Daily Humidity Ranges

<table>
<thead>
<tr>
<th>Mean Daily Humidity Range</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Min</th>
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<tr>
<td>71%</td>
<td>71%</td>
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</tbody>
</table>
# Ambient Design Conditions, 2017

**ASHRAE 1% Occurrences – Chattanooga, TN**

### Annual Cooling, Dehumidification, and Enthalpy Design Conditions

<table>
<thead>
<tr>
<th>Hottest Month</th>
<th>Hottest Month DB Range</th>
<th>Cooling DB/MCWB</th>
<th>0.4%</th>
<th>1%</th>
<th>2%</th>
<th>Evaporation WB/MCDB</th>
<th>0.4%</th>
<th>1%</th>
<th>2%</th>
<th>MCWS/PCWD to 0.4% DB</th>
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</thead>
<tbody>
<tr>
<td>7</td>
<td>18.5</td>
<td>95.0</td>
<td>74.5</td>
<td>92.6</td>
<td>74.2</td>
<td>90.4</td>
<td>73.6</td>
<td>77.7</td>
<td>88.8</td>
<td>76.8</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DP</td>
<td>HR</td>
<td>MCDB</td>
<td>DP</td>
<td>HR</td>
<td>MCDB</td>
<td>DP</td>
<td>HR</td>
<td>MCDB</td>
<td>McWS</td>
</tr>
<tr>
<td>74.9</td>
<td>133.9</td>
<td>81.5</td>
<td>73.8</td>
<td>129.3</td>
<td>80.7</td>
<td>73.0</td>
<td>125.6</td>
<td>80.0</td>
<td>41.5</td>
<td>88.9</td>
</tr>
</tbody>
</table>

- **DB**: Dry Bulb
- **MCWB**: Mean Wet Bulb
- **WB**: Wet Bulb
- **MCDB**: Mean Dry Bulb
- **Enth**: Enthalpy

**Extreme Max WB**: 82.4
## Ambient Design Conditions, 2017
### ASHRAE 1% Occurrences – Chattanooga, TN

<table>
<thead>
<tr>
<th></th>
<th>Cooling</th>
<th>Dehumidification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drybulb</strong></td>
<td>92.6°F</td>
<td>80.7°F</td>
</tr>
<tr>
<td><strong>Wetbulb</strong></td>
<td>74.2°F</td>
<td>75.7°F</td>
</tr>
<tr>
<td><strong>Hum. Ratio</strong></td>
<td>98.0 gr/#</td>
<td>129.3 gr/# (126.5 gr/#)</td>
</tr>
<tr>
<td><strong>Dewpoint</strong></td>
<td>66.5°F</td>
<td>73.8°F</td>
</tr>
<tr>
<td><strong>Enthalpy</strong></td>
<td>37.7 Btu/#</td>
<td>39.2 Btu/#</td>
</tr>
<tr>
<td><strong>Vapor Pressure</strong></td>
<td>0.6563” hg</td>
<td>0.8412” hg</td>
</tr>
</tbody>
</table>
Chattanooga, TN
ASHRAE Climatic Design Conditions
2017 Fundamentals Handbook (1% Occurrence)

- Cooling DB/MCWB
  92.6°Fdb / 74.2°Fwb
  98.0 gr/# / 37.7 Btu/# / 66.5°Fdp
  0.6563 "hg

- Dehumidification DP/MCDB & HR
  73.8°Fdp / 129.3 gr/# / 80.7°Fdb
  75.7°Fwb / 39.2 Btu/#
  0.8412 "hg
Chattanooga, TN
ASHRAE Climatic Design Conditions
2017 Fundamentals Handbook (1% Occurrence)

- Cooling DB/MCWB
  92.6°Fdb / 74.2°Fwb
  98.0 gr/# / 37.7 Btu/# / 66.5°Fdp
  0.6563 "hg

- Dehumidification DP/MCDB & HR
  73.8°Fdp / 129.3 gr/# / 80.7°Fdb
  75.7°Fwb / 39.2 Btu/#
  0.8412 "hg

- Space Neutral DB / %RH
  75°Fdb / 50%RH
  55.1°Fdp / 64.8 gr/#
  23.3 Btu/# (@Sat)
  0.4379 "hg
Divide and Conquer

Typical Dedicated Outside Air System Installation

- Dehumidified Air
- Zone Temperature Control (Terminal Units)
- Humidity Control
Dry Ventilation Air Dries The Building
What is Latent Heat Gain?

\[ Lg = 0.68 \times (Wr - Ws) \times CFM \]

**Where:**
- \( Ws \) = Humidity Ratio Required of Supply Air
  (grains moisture / # dry air)
- \( Wr \) = Humidity Ratio of Return Air (Space)
  (grains moisture / # dry air)
- \( Lg \) = Latent Gain (total, or per person) (BTU/hr)
- \( CFM \) = Ventilation Air Requirement (total, or per person) (cubic feet / minute)
Calculating for the Supply Air Humidity Ratio

\[ Ws = \frac{Wr - Lg}{0.68 \times CFM} \]

Where:

Ws = Humidity Ratio Required of Supply Air (grains moisture / # dry air)

Wr = Humidity Ratio of Return Air (Space) (grains moisture / # dry air)

Lg = Latent Gain (total, or per person) (BTU/hr)

CFM = Ventilation Air Requirement (total, or per person) (cubic feet / minute)
Example: Supply air requirement for an Office Building

Given:
- Design Space Condition of 73°Fdb/50% RH
- Latent Gain per employee of 200 BTU/hr
- Ventilation Rate of 20 CFM/person
- At 73°Fdb/50% RH, the Humidity Ratio (Wr) is equal to 60.6 grains moisture / # dry air

\[ Ws = 60.6 - \frac{200}{(0.68 \times 20)} \]
\[ = 45.89 \text{ gr. moist. / # dry air} \]
\[ = 45.9^\circ F \text{ dewpoint} \]
\[ = 0.0066 \text{ # moisture / # dry air} \]
Example: Supply air requirement for an Operating Room

Given:
- Design Space Condition of 60°Fdb/50% RH
- Latent Gain per person of 200 BTU/hr
- Ventilation Rate of 30 CFM/person
- At 60°Fdb/50% RH, the Humidity Ratio (Wr) is equal to 38.5 grains moisture / # dry air

$$W_s = 38.5 - \frac{200}{(0.68 \times 30)}$$

$$= 28.7 \text{ gr. moist. / # dry air}$$

$$= 33.9 \ ^\circ \text{F dewpoint}$$

$$= 0.0041 \ # \text{ moisture / # dry air}$$
### Notes to Table F-1:

9) Nothing in these guidelines shall be construed as precluding the use of temperatures lower than those noted when the patients’ comfort and medical conditions make lower temperatures desirable.

12) Some surgeons may require temperatures that are outside of the indicated range. All operating room design conditions shall be developed in consultation with surgeons, anesthesiologists, and nursing staff.
What Conditions Do Your Surgeons Desire?

- 67°F db / 50% RH (49°F dp / 48 gr/#)
- 65°F db / 50% RH (46°F dp / 46 gr/#)
- 60°F db / 50% RH (41°F dp / 38 gr/#)
- 55°F db / 50% RH (37°F dp / 32 gr/#)

???????
Proper Application of DH Equipment
There are only 2 ways to remove moisture from the air ...

- Adsorb / Absorb it out
- Condense it out
“Active” Humidity Control

…. Not “Passive”
An Enthalpy Wheel is an example of a Passive Device

.... Not “Active”

So is only designing for Temperature control only and just taking what you can get regarding humidity control.
Dehumidification Technologies

- Desiccant-based Systems: Adsorbs/Absorbs moisture out of the air
  - Solid Desiccants (i.e., wheels)
  - Liquid Desiccants

- Mechanical-based Systems: Condenses the moisture out of the air
  - Chilled Water Coils
  - Direct Expansion (DX) Coils
Actively regenerated desiccant dehumidifier (solid rotor-type, or liquid-type)

Desiccant material adsorbs (solid) or absorbs (liquid) water vapor from the process airstream.

The heat from sorption is removed via cooling coils or heat exchanger after the desiccant rotor.
... or Condense it out

- **Mechanical Dehumidification system**
- The cooling coil cools the process airstream down to, or below, the air’s Dewpoint temperature. Supply air Dewpoint is dependent upon coil temperature.
- Any warming required (i.e., tempering) of this processed air is done after the cooling coil. This is done through a reheat coil (e.g., HW, Steam, Electric, HGRH, etc.) or HX.
Hybrid Desiccant Systems
(i.e., Mechanical & Desiccant)
When to use Desiccant vs. Mechanical?

*(personal opinion)*

Desiccant vs. Mechanical Dehumidification Systems
Mechanical Dehumidifiers

- **Advantages**
  - Higher energy efficiency than desiccants
  - Better understood by most service mechanics than desiccants
  - Equipment generally costs less than desiccants in many circumstances

- **Limitations**
  - Poor cool weather performance vs. desiccants
  - Cannot dry deeply at moderate temperatures
Desiccant Dehumidifiers

- **Advantages**
  - Performance - Dries deeply in all weather conditions, superb capacity and faster response than mechanical
  - Can use low-cost natural gas heat for reactivation

- **Limitations**
  - Needs lots of reactivation heat!
  - Converts moisture to sensible heat, so post-cooling is usually required
  - Less 3rd-party service support available
Section 6.4.3.6 Humidification and Dehumidification. Humidity control shall prevent the use of fossil fuel or electric power to achieve a humidity below 60 percent when the system controlled is cooling, and above 30 percent when the system controlled is heating.

Exceptions:
1. Systems where humidity is removed as the result of the use of a desiccant system with energy recovery (i.e., direct evaporative cooling in series).
2. Systems serving spaces where specific humidity levels are required to satisfy process needs, such as museums and hospitals (e.g., surgical suites, computer rooms, buildings with refrigeration systems, such as supermarkets, refrigerated warehouses and ice arenas, etc). Must keep 10% deadband between Humidification & Dehumidification.
3. Systems serving zones where maintaining not more than +/- 5% RH to comply with applicable codes/accreditation standards.
General Suggestions For Applying ALL Dehumidifiers

- Don’t size them based on supply air flow... size them for moisture removal.
  - Dehumidifiers dry air very deeply. Dry part of the air, then blend the dry air back into the supply. This results in a smaller, less-costly unit.

- Measure and control the air flow through the unit. Otherwise it will not perform.

- Clean all filters at least every month.
  - Dehumidifiers are very costly when used as air filters
  - Low air flow = less DH capacity than intended
More detailed resources from ASHRAE

Indoors, buildings should always be dry. When building interiors get damp and stay damp, problems often emerge for their occupants and for the building’s structure, materials, and furnishings. Persistent indoor dampness has been associated with human health problems, increased risk to buildings’ structural fasteners and exterior enclosures, shortened useful life of furnishings, and reduced acceptability to occupants because of odors and stains. These and related problems can be costly and disruptive, as well as annoying to all concerned (ASHRAE 2013).

**Human Health**

The U.S. National Academy of Medicine and the World Health Organization determined that there is a clear association between damp buildings and negative health effects (NIE 2009). The U.S. Department of Energy’s Lawrence Berkeley National Laboratory estimated the cost of documented dampness-specific health effects to be more than $3.5 billion each year (Modani and Fisk 2007), and

**Avoiding Litigation Risk**

Harmful and moisture-related problems in buildings have been the single largest category of claims against the errors and omissions insurance of architects and engineers (Baker). Also, moisture-related damage is the single most-ignited construction defect against contractors (NAIC 2008).

1. **CAUSES**

Based on investigations of problem buildings, dampness sufficient to cause problems seldom has a single cause. More often, a series of events, including actions by many owners of professional and personal responsibility, combine in complex ways to cause a problem. Therefore, it is not appropriate to assign responsibility for building problems to any single group, because it is not likely that any one group can prevent a problematic level of dampness, mold, or microbial growth by their actions alone.

**MOISTURE MANAGEMENT IN BUILDINGS**

- **CAUSES**
- **MOISTURE TOLERANCE AND**
- **GUIDE**
- **RISK FACTORS AND MITIGATION**
- **HVAC Systems**
- **Architectural Factors**
- **Building Operational Decisions**

<table>
<thead>
<tr>
<th>OCCUPANT DECISIONS</th>
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<tbody>
<tr>
<td>62.5</td>
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<tr>
<td>SOLUTIONS</td>
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<tr>
<td>62.6</td>
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<td>ARCHITECTURE AND DESIGN</td>
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<tr>
<td>Dampness Control and Mitigation</td>
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</table>
It’s not the HEAT ... 
It’s the *Humidity!*