The Need for Ventilation and Moisture Control for Health, Comfort and Sustainability

Nikki Kruger – Industry Manager
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The need for fresh air in a home is nothing new. Every since man has brought fire inside we have recognized the need for ventilation. What is new is the charge to build a house built to codes that completely isolates the great outdoors from the indoors.

This session will address how building codes are driving the need for fresh air ventilation and how these codes can lead to moisture issues in homes. Discussed will be:

- Potential health, comfort and sustainability issues with the implementation of these building practices.
- The advantages and disadvantages of equipment options and control strategies
- Understanding the capabilities and limitations of the HVAC system
- Why dehumidification can be more cost effective than air conditioning
- The benefits of ventilation and dehumidification to the home and its occupants.
Dew Point & Relative Humidity
Humidity is relative to the temperature

The cooler the air, the less energy it has. By reducing the energy the molecules need to escape the liquid bonds and become a gas – condensation is created. Heating the air adds energy and encourages evaporation.
For each 1 degree the temperature increases, the relative humidity decreases 2%
Most Humid Location in the United States?

Due to their proximity to moisture and cool temperatures, island and coastal areas in Alaska are the most humid spots in the nation. Saint Paul Island, Alaska, has the highest average afternoon relative humidity (83%).

Average afternoon temperatures are 28° - 49° F
Dew Point

The dew point is what the air temperature would have to be for relative humidity to be at 100%.

Unlike RH, the dew point does not change with air temperature. In that sense it is an “absolute” measurement of the amount of water vapor in the air.
How Do I Calculate Dew Point?

If you know temperature and relative humidity, you can calculate the dew point.
The glass of water is 73° F. All of the listed temperatures will produce condensation on a 73° F surface.

- A wet surface grows mold after 24 hours.
- Raising the temperature of the air does not stop condensation.
- Lowering the dew point of the air stops condensation.
- Warming the surface temperature above the dew point stops condensation.
Why Do I Have Condensation?

If the dew point is above the surface temperature, condensation will occur.

If the dew point is below the surface temperature, there will be no condensation.
Dew Point’s Across the Nation

[Map showing dew point temperatures across the United States, with different color coding for various temperature ranges.]
Dew point is fairly uniform throughout the day and night.

This is for a green grass climate region.

Sensible load
—
High most of the time

Latent load—
High most of the time

A Rainy Day is Different

Sensible load
—
Low

Latent load—
High most of the time

Dew Point

- 70°F Dew Point
- 74°F
- 98°F
- 88% RH
- 42% RH

24-hour Moisture Load: Hot, No Rain

Accumulated over the period: 0 in

RAIN - RAIN GAUGE

0.059
Thermodynamics Basics
Today’s Building Practices
Health, Comfort & Structure
Building Codes

Current Residential Building Energy Code Adoption Status

* Adopted new Code to be effective at a later date

Source: Department of Energy
2012 IECC – Air Tightness

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>2009 IECC</th>
<th>2012 IECC</th>
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<tbody>
<tr>
<td>1 - 2</td>
<td>&lt; 7 ACH</td>
<td>≤ 5 ACH @ 50 pascals</td>
</tr>
<tr>
<td>3 - 8</td>
<td>&lt; 7 ACH @ 50 pascals</td>
<td>≤ 3 ACH @ 50 pascals</td>
</tr>
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Table 1: 2009 vs. 2012 IECC Comparisons

Source: Department of Energy
2012 IECC- Ventilation

IMC, Section 401.2 Ventilation Required
Where the air infiltration rate in a dwelling unit is less than 5 air changes per hour when tested with blower door at a pressure of 0.2-inch water column (to Pa) in accordance with Section 402.4.1.2 of the International Energy Conservation Code, the dwelling unit shall be ventilated by mechanical means in accordance with Section 403.

2,000 square ft. house will need approximately 90 CFM of fresh air according to the 2013 ASHRAE 62.2 Standard

This is up from 50 CFM in the 2010 ASHRAE 62.2 Standard

Source: Department of Energy
“Locating the air distribution system ducts inside conditioned space saves energy overall, but with the reduced sensible cooling load, also comes an increased need for supplemental dehumidification.”

“…mechanical ventilation, operated at the ASHRAE 62.2-2010 addendum r rate, in a 3 ach50 house, raises the annual median indoor RH by almost 10% RH compared to a 7 ach50 house without mechanical ventilation in Orlando.”

U.S Department of Energy: Recommended Approaches to Humidity Control in High Performance Homes by Armin Rudd

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Table 1: 2009 vs. 2012 IECC Comparisons

Source: Department of Energy
The Need for Dehumidification is Significant

High indoor humidity levels affect:

- Health
- Comfort
- Personal belongings
- Structure of our homes

Less than 50% RH

“Most comfortable when the relative humidity range is between 25-60%”
Health and Well Being

**Optimum relative humidity range to minimize harmful contaminants**
(a decrease in bar height indicates a decrease in effect for each of the items)

*ASHRAE: American Society of Heating, Refrigeration & Air Conditioning Engineers*
AIR CONDITIONING

• Designed to reach a temperature set-point (sensible)
• New units have dehumidification set-points – still cooling

A common misperception is that hot, humid days are the most challenging days to control moisture in a home. But in these conditions the air conditioner runs a lot in order to cool the home, and removes moisture in the process.

Days that you need to be most concerned about are when it is 70°F and raining.
1 Ton A/C Provides:

12,000 BTU per hour of cooling-
  • 10,000 BTU of sensible cooling
  • 2,000 BTU of latent cooling

2 lbs. per hour of dehumidification-
  Uses the first 1 lb. of condensate per ton of coil to load the coil/pan

The typical A/C setup takes 30 minutes of runtime to wet the coil and drain pan. This is before the first drop of condensate drains out.
Seasonal Energy Efficiency Ratio (SEER)

The SEER rating of a unit is the cooling output during a typical cooling-season divided by the total electric energy input during the same period. The higher the unit's SEER rating the more energy efficient it is.

**High SEER AC**

- Larger coils that are very efficient at getting to a cool temp quickly equals less run time.
  
  **Typical coil holds 1 pound of water per ton**
- Coils do not get as cold as older AC systems
  
  **Less water removed from air and going down drain**
- High efficiency A/C run 1-3 minutes fan delays at end of cycle to increase SEER rating.
  
  This increases the SEER rating by .5
- **Can increase indoor RH by up to 10%**
Variable Speed

- Slows air conditioner fan down to remove more moisture
- A/C makes a smaller amount of colder air
- Colder surfaces (ducts, registers, etc.) may result in condensation
- Doesn’t solve 70°F/raining
### 3 Ton Heat Pump Specs at Various Conditions

<table>
<thead>
<tr>
<th>Entering Wet Bulb Temperature</th>
<th>Total Air Volume</th>
<th>Total Cooling Capacity</th>
<th>85°F (29°C)</th>
<th>Sensible To Total Ratio (S/T) Dry Bulb</th>
<th>Total Cooling Capacity</th>
<th>Sensible To Total Ratio (S/T) Dry Bulb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cfm</td>
<td>L/s</td>
<td>kBtu/h</td>
<td>Comp Motor kW Input</td>
<td>kW</td>
<td>75°F 24°C</td>
</tr>
<tr>
<td>63°F (17°C)</td>
<td>1050</td>
<td>495</td>
<td>34.8</td>
<td>10.2</td>
<td>2.44</td>
<td>80°F 27°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.74</td>
<td></td>
<td>85°F 29°C</td>
</tr>
<tr>
<td></td>
<td>1300</td>
<td>615</td>
<td>35.9</td>
<td>10.5</td>
<td>2.36</td>
<td>95°F 35°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.79</td>
<td></td>
<td>80°F 27°C</td>
</tr>
<tr>
<td></td>
<td>1600</td>
<td></td>
<td></td>
<td>.90</td>
<td></td>
<td>85°F 29°C</td>
</tr>
</tbody>
</table>

Raising the air flow from 350 to 530 cfm per ton increases the sensible ratio to .90 (thus decreasing the latent ratio to .10). This favors sensible cooling rather than humidity removal.

The increased airflow drops the dehumidification to <1 lb. of moisture removal per ton. More airflow forces the cold indoor coil to run warmer.
The A/C is incapable of lowering the indoor dew point below 59°F. There is not enough sensible load.
Fresh Air Ventilation

The driving force for the development of ventilation standards is the fact that indoor air quality affects both comfort and health.

- Big debate is how much fresh air should be the standard
  - Everyone responds differently to pollutants
  - Bringing in fresh air costs $$$$
Fresh Air Ventilation

**Balance** - Balanced ventilation systems use one fan to bring fresh air into the home and another to exhaust an equal amount to the outdoors.

**Supply** - Supply ventilation systems push air into the home creating a slight positive pressure and provides make-up air for kitchen hoods and bathroom fans.

**Exhaust** - Exhaust ventilation systems pull stale air out of the home creating a negative pressure in the house and rely on make-up air leakage through the structure.
How Moisture, Temperatures and Wind Affect the Home
Let's start with one cubic foot of air. A typical home has 20,000 cubic feet inside the walls.

To be healthy, ASHRAE suggest an air change in 4-5 hours. This purges indoor pollutants and renews oxygen.
1. Let us focus on the amount of moisture in 1 cubic foot of air at specific temperatures and 100% relative humidity (RH).

2. There are 7,000 grains of moisture in a pint or lb. of water.

3. 1.4 drops of liquid water equals 1 grain of moisture vapor or 1 drop of water equals .7 grains. Call a grain of moisture a big drop.
Homes imperfections allow air infiltration and exfiltration

1. Wind
2. Stack effect
3. Mechanical fans
Fresh Air Infiltration – Cold and Windy Climate

Unheated Home

0°F, 100% RH, 0°F DP
infiltrating air

0°F, 100% RH, 0°F DP
air

0°F, 100% RH
exfiltrating air
Fresh Air Infiltration – Cold and Windy Climate

Heated Home

Inside Home
70°F, 6% RH, 0°F DP

Outside Air
0°F, 100% RH, 0°F DP infiltrating air

Air Leaving the Home
70°F, 6% RH exfiltrating
An occupant adds about \( \frac{1}{4} \) lb of moisture (breathing) plus \( \frac{1}{4} \) lb from activities to a home per hour.*

4 occupants add 2 lbs. (14,000 grains) per hour of moisture to the home.

*ASHRAE
Fresh Air Infiltration – Winter

Heated Home

Inside Home
70°F, 35% RH, 41°F DP

0°F, 100% RH infiltrating air

70°F, 35% RH exfiltrating air
Home with Spray Foam & Mechanical Ventilation Fresh Air Infiltration – Winter

Heated Home

70°F, 60% RH, 55°F DP

0°F, 100% RH infiltrating air

House needs 100 CFM of mechanical ventilation
Fresh Air Infiltration
Summer

Air Conditioned Home

85°F, 95% RH, 83° DP

75°F, 50% RH, 55° DP

Ultra-Aire™
WHOLE HOUSE VENTILATING DEHUMIDIFIERS
**Fresh Air Infiltration – Spring/Fall**

No Heating or Cooling

<table>
<thead>
<tr>
<th>°F</th>
<th>% RH</th>
<th>Dew Pt</th>
</tr>
</thead>
<tbody>
<tr>
<td>67</td>
<td>97</td>
<td>67</td>
</tr>
<tr>
<td>68</td>
<td>98</td>
<td>68</td>
</tr>
<tr>
<td>69</td>
<td>99</td>
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<td>70</td>
<td>100</td>
<td>70</td>
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<td></td>
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<td>72</td>
<td></td>
<td></td>
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<tr>
<td>73</td>
<td></td>
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</tr>
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</table>

Flow

- **Inlet**: 70°F, 100% RH
- **Outlet**: 70°F, 50% RH

100 cfm of 70°F, 100% RH

70°F, 50% RH, 50°F DP

100 CFM Ventilation

70°F, 100% RH, 70°F DP

**Note:** The image includes a diagram illustrating the flow of air and temperature changes, with arrows pointing to different data points.
## Moisture Removal Required per 100 cfm of Outdoor Air Infiltration

<table>
<thead>
<tr>
<th>Indoor °F, %RH</th>
<th>Lbs. per hour Required Moisture Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>70°F, 45% RH, 48°F DP</td>
<td>.3 1 2 3 4 5.3 7</td>
</tr>
<tr>
<td>70°F, 50% RH, 50°F DP</td>
<td>3.6 5.1</td>
</tr>
<tr>
<td>75°F, 60% RH, 52°F DP</td>
<td>0 3.3 4.8</td>
</tr>
<tr>
<td>75°F, 50% RH, 55°F DP</td>
<td>0 1 2 3 4.3 6</td>
</tr>
<tr>
<td>80°F, 50% RH, 60°F DP</td>
<td>0 1 2 3.5 5</td>
</tr>
<tr>
<td>90°F, 50% RH, 69°F DP</td>
<td>.3 1.6 3.2</td>
</tr>
</tbody>
</table>

Rainy days, evenings, and design days (lbs. per hour, moisture)

Dew Point Temperature of Infiltrating Air
Whole House Dehumidification Vs. ERV

*“…the ERV is ineffective in keeping indoor RH down during floating hours when the difference between indoor and outdoor absolute humidity is small.”*

*U.S Department of Energy: Recommended Approaches to Humidity Control in High Performance Homes by Armin Rudd*
Ventilation Electrical Usage

Power rating [W] = 580
Days per year in use = 150
Hours per day in use = 24
Minutes per hour in use = 20
Avg cost per kWh = 0.14

Annual usage time [hr] = 1200
Annual electrical usage [kWh] = 696
Annual electrical cost = 97.4

Best Ways to Decrease the Indoor Relative Humidity

1. Maintain ideal ventilation rate when occupied.
2. Add a correctly sized whole house dehumidifier.
3. Setup a/c to provide air <45°F dew point air/cooling.
4. Fix duct and building air leaks.

Questions?