Managing HVAC in High Performance Buildings
Ultra-Aire is one of five brands manufactured in Madison, WI under Therma-Stor, LLC.

Our company, established in 1977, is considered the pioneer of whole-house dehumidification and premier manufacturer of dehumidifiers and heat reclaim products.
Definitions and Terminology

**Sensible Load** is the temperature you feel on your body and measured with a thermometer. This is controlled with the HVAC thermostat.

**Latent Load** is the moisture in the air often referred to as relative humidity. This is more challenging to control with the HVAC thermostat.
A pint is a pound the world around

It takes 1,000 btus to remove one pint of water

1 cfm in = 1 cfm out
While the amount of water in the air remains the same, the % of the air that the water occupies changes with the temperature; therefore, the amount of space that the water occupies is relative to the temperature of the air.
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.
DEW POINT’S ACROSS THE NATION

Dehumidification to maintain 75°F, 50%RH, 55°F dew point -- 0 1 3 6 Lbs. per hour per 100 CFM

Current Dew Points in the United States

Needs 1-6 pints/hour dehumidification per 100 cfm of fresh air @ 75°F, 50%RH 55°F dew point indoors

Damp Spot

Today

Click regional dew point maps below for more information

Created: Friday Oct 06 11:50 AM EDT
Advances = Low-Sensible Load Houses

<table>
<thead>
<tr>
<th>Continuous Insulation</th>
<th>Sensible Cooling Load</th>
<th>Latent Cooling Load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Tight Construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimized Windows/Shading</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Ventilation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ducts in Conditioned Space</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
One person adds about $\frac{1}{4}$ pint of moisture from breathing plus $\frac{1}{4}$ pint from activities to a home per hour.

4 occupants add 2 pints (14,000 grains) of moisture to a home per hour.
THE NEED FOR DEHUMIDIFICATION IS SIGNIFICANT

High indoor humidity levels affect:

- Health
- Comfort
- Personal belongings
- Structure of the home

Less than 50% RH

Less Than 60% RH

“Most comfortable when the relative humidity range is between 25-60% ”

Less than 50% RH

Less Than 60% 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)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Optimum Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria</td>
<td></td>
</tr>
<tr>
<td>Viruses</td>
<td></td>
</tr>
<tr>
<td>Fungi</td>
<td></td>
</tr>
<tr>
<td>Mites</td>
<td></td>
</tr>
<tr>
<td>Respiratory Infections</td>
<td></td>
</tr>
<tr>
<td>Allergic Rhinitis &amp; Asthma</td>
<td></td>
</tr>
<tr>
<td>Chemical Interactions</td>
<td></td>
</tr>
<tr>
<td>Ozone Productions</td>
<td></td>
</tr>
</tbody>
</table>

*ASHRAE: American Society of Heating, Refrigeration & Air Conditioning Engineers*
The ultimate goal in every energy efficiency building standard program is to build a tight envelope to reduce the amount of run time on the HVAC system to save energy.

**THE RESULT**

- Higher Seasonal Energy Efficiency Ratio (SEER) equipment specified.
- Partial to no-load on the AC system, even in hot and humid climates.
- More efficient sensible cooling at the expense of latent removal capacity, resulting in (inefficient) overcooling to remove moisture.
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, which removes moisture in the process.

Days that you need to be most concerned about are when it is 70°F and raining.
Typical residential HVAC systems need 14 minutes of run time to begin effective dehumidification.
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 70ºF/raining
DUCTLESS MINI-SPLIT

- Only focuses on the space the unit is located in.

- Cools the space very quickly, but often not enough run time to remove moisture in the space.

- **Dehumidification Mode** is simply setting it to run in air cooling mode for a longer period of time, which leads to occupant discomfort and possible microbial growth due to materials reaching dew point.
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 means less run time. **Typical coil holds 1 pint of water per ton**
- Coils do not get as cold as older AC systems. **Less water removed from air and going down the drain**
- High efficiency A/C runs 1-3 minute fan delays at end of cycle to increase SEER rating. **Increases the SEER rating by .5**
- Can increase indoor RH by up to 10%
HVAC system has been sized according to industry best practices, is installed, and money collected. Some would consider this done – right?

WRONG!

Concern – the system has been sized for peak load conditions, but the house sees mostly partial and no-load conditions.
### Whole House Load Calculator

<table>
<thead>
<tr>
<th>Outside Wall:</th>
<th>Windows</th>
<th>Glass Doors</th>
<th>Doors</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>2</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>South</td>
<td>2</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>E &amp; W</td>
<td>2</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>NE &amp; NW</td>
<td>2</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>SE &amp; SW</td>
<td>2</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Sky Lights</td>
<td>E-W:</td>
<td>NE-NW:</td>
<td></td>
</tr>
<tr>
<td>Floor</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceiling</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Appliances</td>
<td>2</td>
<td>Firesides</td>
<td>1</td>
</tr>
<tr>
<td>Number of People</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Btu's Cooling**: 36577  **Sensible Load**: 29407  **Latent Load**: 7170  **Total Btu's Heating**: 42432

Sizing Calculator based on Manual S
Sensible Loads Vary – Latent Loads Stay Uniform

Sensible Load
90% to near zero most days

Latent load is fairly uniform throughout the day and night

Manual J is 1 hour of peak load
HOW DO I KNOW HOW MUCH DEHUMIDIFICATION A HOME NEEDS?

Select the corresponding button to change the picker view. The red light indicates the calculated variable, click on one of the green lights to change the calculated variable.
ERVs and HRVs are balanced ventilation systems originally developed for northern climates. They bring air into the home and blow an equal amount of air out of the home. The ERV/HRV core transfers some heat, and in an ERV moisture (energy), between the two air streams.
*"...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*
CASE STUDY | AFFORDABLE MULTI-FAMILY HOUSING

- Located in Climate Zone 4
- Constructed in 2015
- Two-stage cooling equipment installed
- Significant mold issues caused by excessive humidity in several of the units during the summer of 2017
Two-stage cooling equipment was installed with the understanding that the equipment would provide better moisture control. As it turned out, these two-ton condensing systems were grossly oversized for the one-bedroom units.

Reading taken in the apartment showed 74% RH and 66°F (above).

As a result, mold began to form on the walls (right).
The tenant was temporarily relocated while the unit was remediated and an Ultra-Aire MD33 In-Wall Dehumidifier was installed.

Almost immediately, the RH stabilized in the 50% range, while the interior temperature was maintained at a comfortable and affordable 75°F.

The resident reported an immediate difference in the feel of her apartment with the sticky, clammy feeling now eliminated.
Home was build tight

HVAC system was sized according to Manual J

Bringing in outside air to meet ASHRAE or other standard

- We have reduced the sensible loads on the home but the latent loads have not changed and possibly increased.
- High efficiency HVAC equipment can not always be counted on to keep homes dry, healthy and comfortable.

ACCA Manual LLH will look at:
- Resolving ventilation requirements (for occupant health and safety) while maintaining moisture control.
- Addressing ancillary dehumidification equipment for humid locations (e.g., DOE Type A climate zones require ancillary dehumidification).