Laboratory Performance
Testing of Residential Dehumidifiers

Building America Stakeholders Meeting

Jon Winkler

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Motivation

• Solution: Performance map across a variety of operating conditions

\[ \text{Performance} = f(T_{in}, RH_{in}) \]
Laboratory Test Report for Six ENERGY STAR® Dehumidifiers

Jon Winkler, Dane Christensen, and Jeff Tomerlin

NREL/TP-5500-52791

December 2011

http://www.nrel.gov/docs/fy12osti/52791.pdf
Tested Dehumidifiers

<table>
<thead>
<tr>
<th>Brand Name</th>
<th>Model #</th>
<th>Capacity(^1) (pints/day)</th>
<th>Energy Factor(^1) (L/kWh)</th>
<th>Airflow Rate(^2) (cfm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra-Aire</td>
<td>XT150H</td>
<td>150</td>
<td>3.7</td>
<td>415(^2)</td>
</tr>
<tr>
<td>Ultra-Aire</td>
<td>70H</td>
<td>70</td>
<td>2.32</td>
<td>160(^2)</td>
</tr>
<tr>
<td>Santa Fe(^3)</td>
<td>Compact</td>
<td>70</td>
<td>2.37</td>
<td>170(^2)</td>
</tr>
<tr>
<td>General Electric (GE)</td>
<td>ADER65LP</td>
<td>65</td>
<td>1.8</td>
<td>195/175/155</td>
</tr>
<tr>
<td>Soleusair</td>
<td>SG-DEH-45-1</td>
<td>45</td>
<td>1.5</td>
<td>103/91/81</td>
</tr>
<tr>
<td>Comfort Aire</td>
<td>BHD-301-G</td>
<td>30</td>
<td>1.4</td>
<td>N/A</td>
</tr>
<tr>
<td>Frigidaire</td>
<td>FAD251NTD</td>
<td>25</td>
<td>1.2</td>
<td>N/A</td>
</tr>
</tbody>
</table>

\(^1\) Performance at the rated inlet condition of 80°F, 60% relative humidity (RH) (AHAM 2008)

\(^2\) Flow rate specified at 0 in. water gauge (WG)

\(^3\) Unit was tested under a reduced set of operating conditions due to nearly identical performance with the Ultra-Aire 70H

• **Steady state testing**
  - Water removal rate
  - Energy factor

• **Units with multiple fan settings were tested at the highest flow rate only**
Test Setup – Ducted Units
Test Setup – Standalone Units
Test Conditions

- UltraAire XT150H Test Points
- Comfort Aire Test Points
- Remaining Dehumidifier Test Points
- Winter Comfort Region
- Summer Comfort Region

Dry Bulb Temperature (°C) vs. Relative Humidity (RH)

AHAM Rating Point
## Measured Performance

<table>
<thead>
<tr>
<th>Dehumidifier</th>
<th>Capacity (pints/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rated</td>
</tr>
<tr>
<td>Ultra-Aire - XT150H¹</td>
<td>150</td>
</tr>
<tr>
<td>Ultra-Aire - 70H</td>
<td>70</td>
</tr>
<tr>
<td>General Electric</td>
<td>65</td>
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<tr>
<td>Soleusair</td>
<td>45</td>
</tr>
<tr>
<td>Comfort Aire</td>
<td>30</td>
</tr>
<tr>
<td>Frigidaire</td>
<td>25</td>
</tr>
<tr>
<td>Dehumidifier</td>
<td>Capacity (pints/day)</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td></td>
<td>Rated</td>
</tr>
<tr>
<td>Ultra-Aire - XT150H</td>
<td>150</td>
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<tr>
<td>Frigidaire</td>
<td>25</td>
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</tbody>
</table>
Performance Modeling

• **Rated performance inputs**
  - Water removal rate (L/day)
  - Energy factor (L/kWh)
  - Air flow rate (m³/s)

• **Normalized curves to adjust rated performance**
  - Water removal rate
  - Energy factor

\[
\text{factor} = a + b \cdot T_{in} + c \cdot T_{in}^2 + d \cdot RH_{in} + e \cdot RH_{in}^2 + f \cdot T_{in} \cdot RH_{in}
\]

• Report includes curve fit coefficients for actual and normalized performance
Energy Factor Performance Curves

Ultra-Aire – 70 pint/day

Frigidaire – 25 pint/day

GE – 65 pint/day

Ultra-Aire – 150 pint/day

Entering DB Temperature (°C)

Normalized Energy Factor

RH = 80%

RH = 70%

RH = 60%

RH = 50%

RH = 40%
Generic Performance Curves

• 77 test points used in regression
• r-squared values of 0.98 and 0.97 for water removal rate and energy factor, respectively

Mean Absolute Percentage Errors

<table>
<thead>
<tr>
<th>Dehumidifier</th>
<th>Water Removal Rate</th>
<th>Energy Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra-Aire - XT150H</td>
<td>6.5%</td>
<td>5.3%</td>
</tr>
<tr>
<td>Ultra-Aire - 70H</td>
<td>4.4%</td>
<td>3.0%</td>
</tr>
<tr>
<td>General Electric (65)</td>
<td>4.2%</td>
<td>5.7%</td>
</tr>
<tr>
<td>Soleusair (45)</td>
<td>4.8%</td>
<td>4.5%</td>
</tr>
<tr>
<td>Comfort Aire (30)</td>
<td>4.6%</td>
<td>4.8%</td>
</tr>
<tr>
<td>Frigidaire (25)</td>
<td>5.3%</td>
<td>5.8%</td>
</tr>
<tr>
<td>All Tested Units</td>
<td>5.0%</td>
<td>4.8%</td>
</tr>
</tbody>
</table>
Building America Gaps and Barriers

• **Gaps** ([http://www1.eere.energy.gov/buildings/building_america/strategic_plan.html](http://www1.eere.energy.gov/buildings/building_america/strategic_plan.html))
  
  o Space Conditioning  
    – “Need to Understand Operating Performance of Existing and Emerging Supplemental Dehumidification Equipment”
  
  o Analysis Methods and Tools  
    – “Supplemental Dehumidification Modeling”

• **Achievements**
  
  o NREL – Tested six vapor compression dehumidifiers

• **Planned or Ongoing Research**
  
  o GTI/PNNL – Performance testing several desiccant-based residential dehumidifiers
Future Work

• What is left to achieve?
  o Characterize the performance of centralized equipment with explicit humidity control
  o Characterize part-load/cycling losses
  o Continually observe market landscape and test high penetration and emerging equipment

• Additional questions?
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