Western Cooling Efficiency Center Workshop on Modern Evaporative Cooling Technologies
July 9-10, 2007, Boulder, Colorado

ADVANCED ROOFTOP UNITS
Howdy Reichmuth, Sr. Engineer
Indirect Evaporative Hybrid – the Desert CoolAire™ Unit
Desert CoolAire™ Package Rooftop Unit

“Hybrid” = Indirect Evap + Dx Cooling + gas pack

- Refrigerant Capacity (DX): 48,000 btu
- Total Cooling Capacity: 60,000 btu
- Total Heating Capacity: 115,000 btu
- Compressor: 10-100% Digital modulating scroll
- VFD Blower
- Supply Air: 1800 CFM at 1 inch ESP
Indirect Evaporative Cooling - Maisotsenko-Cycle
The Delphi HMX
formerly manufactured by Coolerado
Monitoring, Etc.
Monitoring Done By AEC

- One-minute data internet accessible
- Aggregated to one-hour data by mode
- Complemented by site measurements
Core Performance 1
A typical indirect evaporative cooling “moment”
Core Performance 2
Performance varies with outdoor temperature

Evaporator Performance

Inlet Dry Bulb Temperature, deg F

Temperature Depression, deg F

Wet Bulb Depression
Dry Bulb Depression
Core Performance 3

Evaporative efficiency varies with airflow

Wet Bulb Efficiency and Operating Pressure

Inlet Air Dry Bulb Temperature, deg F

Wet Bulb Efficiency

- WBE .6 in WC
- WBE 1.2 in WC
Sacramento

CoolAire Site #17

09/06/06 - 09/06/06

32°F cooling from the HMX core!
Water Performance 1

Water use varies with outdoor temperature

Water Use Model - site 13

Water use, Gph

Room Temperature
Water Performance 2
Water use compared to theoretical minimum water need

Actual Water Use vs Theoretical Water Use

Outside Air Temperature, deg F
Water Use, Gph
Water Performance 3
Water Performance Compared to Maximum Allowed

Observed Flow vs Limit of .15 gpm/ton

- observed
- MAX
- New Control - as is
- New Control - best
Location, location, location

- Applicability of indirect evaporative cooling depends on entering wet bulb
- Overall efficiency depends on high need for cooling
- Equivalent psychrometric presentation in terms of web bulb and dry bulb
Low Cooling Situation

![Cooling Conditions Seattle - July TMY2](image)

- Dry Bulb Temperature, deg F
- Wet Bulb Temperature, deg F
- OSA
- Comfort
- saturation
- indirect evap limit
- evap exit
High and Dry Cooling

Cooling Conditions Boise - July TMY2

- Dry Bulb Temperature, deg F
- Wet Bulb Temperature, deg F

- OSA
- Comfort
- saturation
- indirect evap limit
- evap exit
Cooling Conditions Sacramento - July TMY2

- OSA
- Comfort
- saturation
- indirect evap limit
- evap exit
Difficult Cooling

Cooling Conditions Phoenix - July TMY2

- Dry Bulb Temperature, deg F
- Wet Bulb Temperature, deg F

Legend:
- OSA
- Comfort
- Saturation
- Indirect evap limit
- Evap exit
Hourly Energy Comparison

- high cooling case

Time of day

Hourly Energy, kWh

as operated — SEER 13 — best operation
Desert CoolAire Results - draft

Hourly Demand Comparison

- Hi cooling case

Time of day

KWh

Hourly Demand

7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00

as operated

SEER 13
Desert CoolAire Results - draft

Hourly Demand Comparison
- medium cooling case

Hourly Demand, kW

Time of day

as operated  SEER 13
CoolAire Performance Comparison

<table>
<thead>
<tr>
<th>System</th>
<th>Avg. Daily EER</th>
<th>Tmax Hour EER</th>
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<tbody>
<tr>
<td><strong>Reference</strong></td>
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<td>15</td>
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<td>Gen2</td>
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EER Comparison of CoolAire and Reference Systems

High Cooling Case (Tmax 103F)
Prototype Findings

- Energy Savings 6 - 23%
- Demand Savings 33 – 49%
- No Media Scaling*
- Non-optimal Prototype Design & Control (excessive fan energy, overuse of Dx, too much H2O)
- Possible 20%+ improvement with redesign

* 6 month observation
Steps to Commercial Intro

- Lighter, Smaller and Cheaper
- Easier install
- Greater energy savings for owners
- Training on evap for standard RTU contractors
- Market the benefits
- Extend applications/change HVAC design – eg. Dedicated Outside Air Systems (D-OAS)
Q & A
Evaporative Cooling Challenges

• Old direct evaporative technology image
• Managing mineral scale
• Putting water usage in context
• Potential changes to ventilation design for higher airflow rates
• Lack of recognition in codes and HVAC efficiency ratings
• Lack of knowledge on the part of owners, contractors, designers, facility managers
• Advanced evap. vendors too small
• Limited regulatory, policy & utility involvement