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Desiccant Dehumidification Performance Lessons

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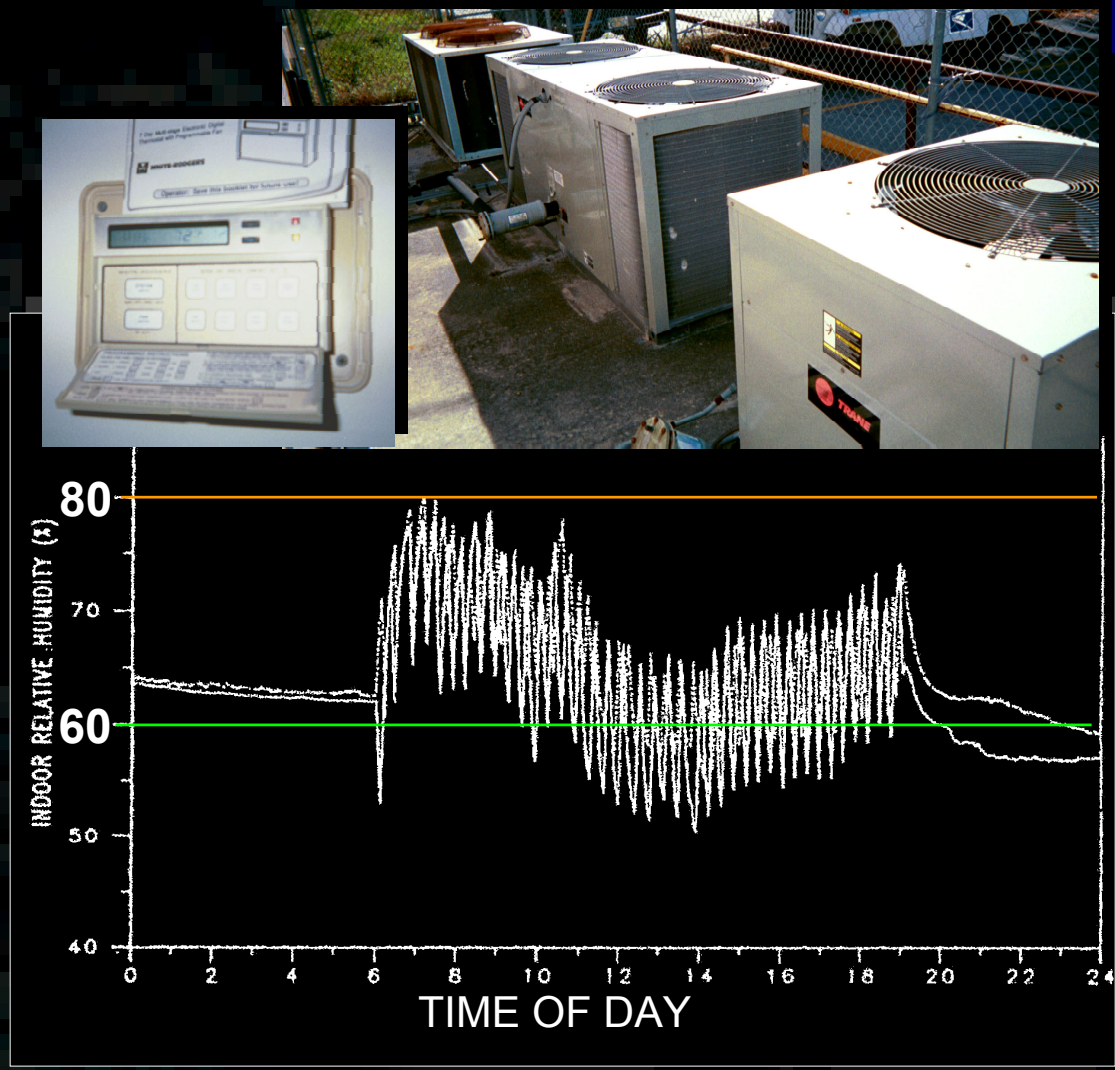
Desiccant Dehumidification Performance Lessons

-or- "Desiccants: The Good, the Bad, and the Ugly"

- How desiccant units work (or don't work)
- Comparison of *Desiccant* to *DX/gas reheat, Energy Recovery Wheels, all-electric DX* … annual costs
- Results of detailed measurement and verification
- Why it's beneficial to precondition ventilation air
- How to get the good without the bad and the ugly

Problem with Excessive Humidity

- No call for sensible cooling at certain times of day/year
- Dehumidification is still needed
- Compressor cycles off once thermostat is satisfied
- Condensate evaporates off coil
- Humidity swings



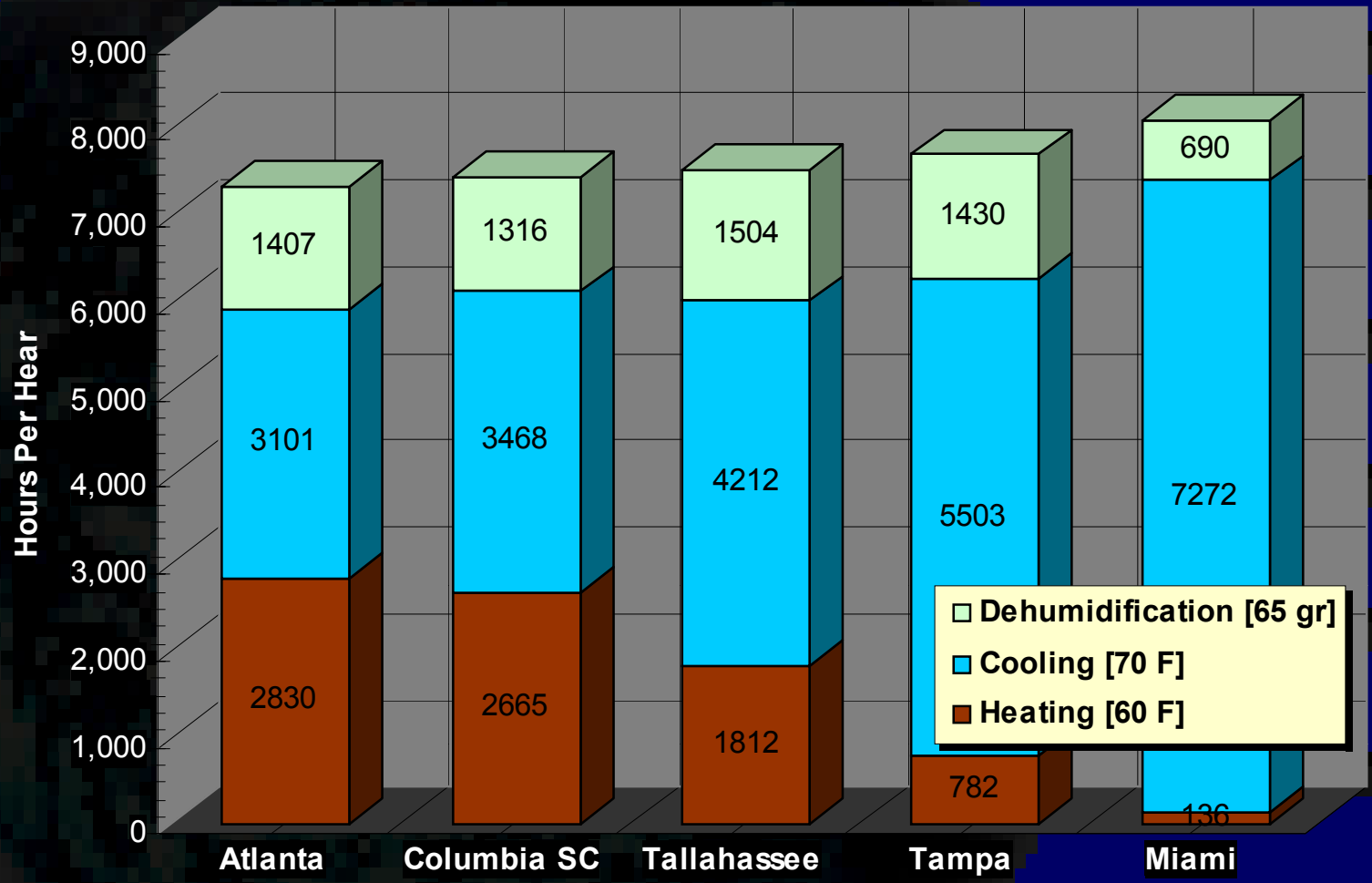
Conditioning Ventilation Air

- Most of a building's humidity load is from the HVAC intake of fresh outside air
- The need to condition outside air is mostly dehumidification (mostly = 86% here in Orlando)
  - in terms of annual BTUs: 172 latent & 28 sensible MBTU/cfm
- There are many types of ventilation pretreatment units available
  - These units can dehumidify without cooling
  - Units can be grouped into *DX-cooling/reheating* and *desiccant* types and compared

Why was desiccant selected?

- Separate conditioning of outside air with dedicated equipment has advantages
  - Allows separate treatment of the latent load
  - Dehumidification can always be provided, even when there is no cooling load
- Desiccant units have two key advantages
  - Capable of supplying very dry air
  - Powered mostly by heat from natural gas and/or other sources such as waste heat and solar heat
    - Fuel diversity
    - Avoided kW demand charges
    - $/kWh compared with $/Therm rates

Dehumidification-only is needed for about 25% of the cooling/dehumidification hours



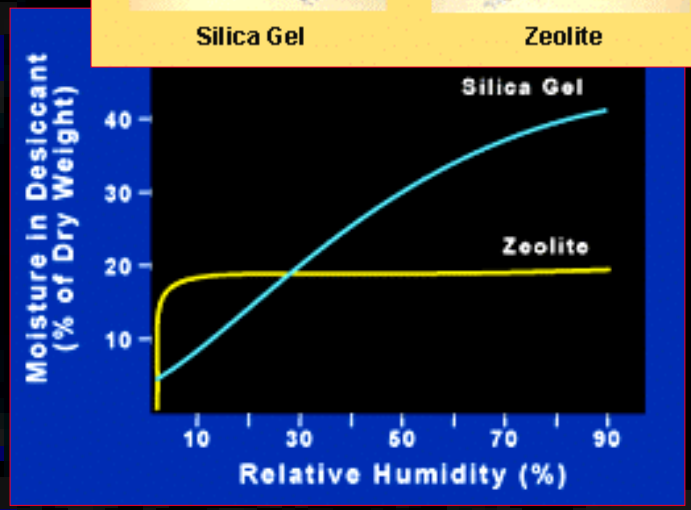
Untreated Outside Air Causes Problems

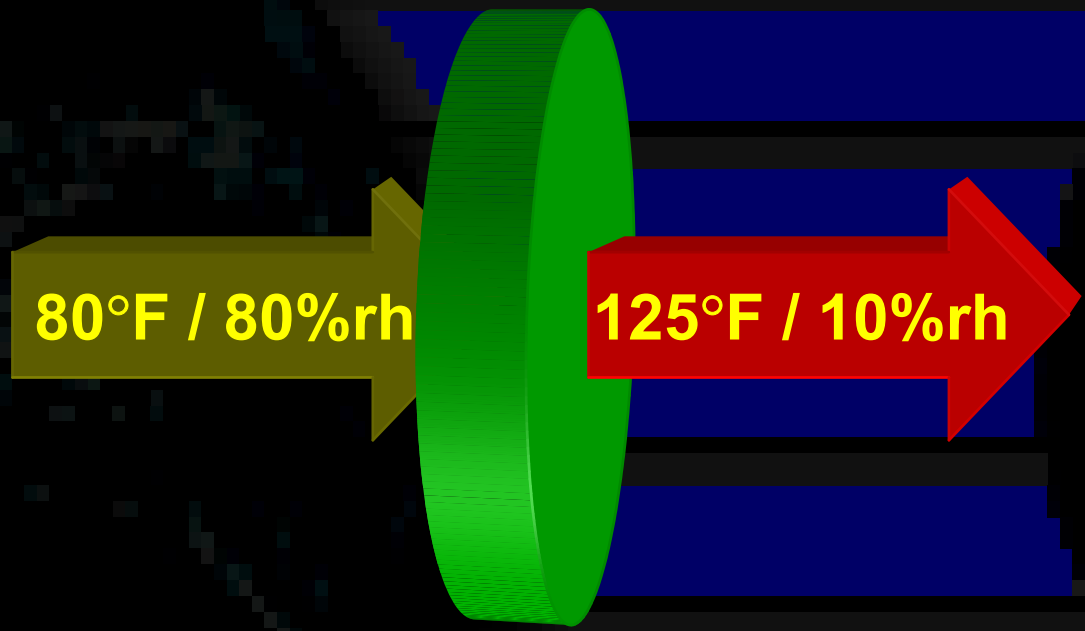
- Excess humidity, poor IAQ, and/or high energy costs are common concerns
- Problems occur when standard HVAC units are used to treat a relatively large outside air flow
- High occupant density, large exhaust fans, leaky envelope
- Worse in combination with relatively low sensible load

Limitations of DX & CHW Units

- Only 20% to 40% of capacity is dehumidification
  - 60% to 80% is sensible cooling
- Typically controlled by thermostat only
  - Humidistat typically energizes expensive reheat

Desiccant Adsorption

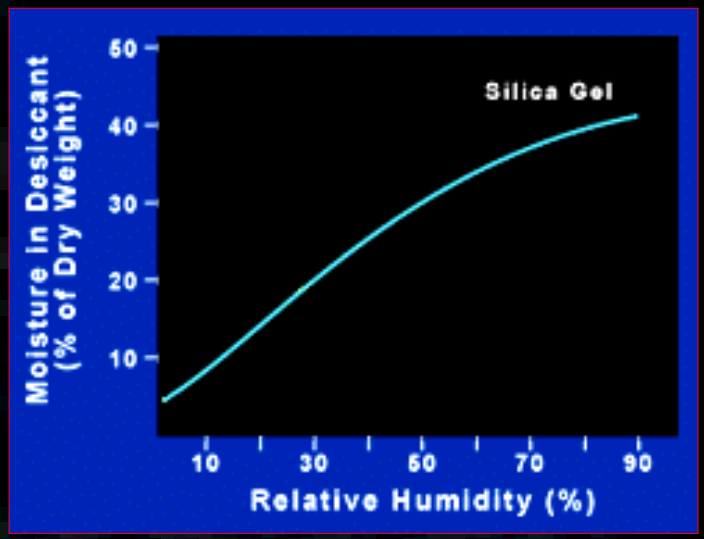


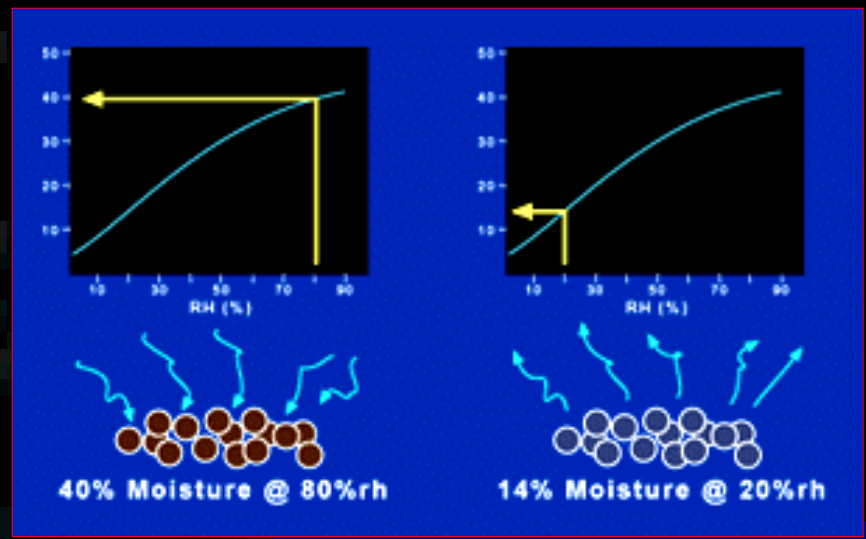


- Unit uses wheel made with Silica Gel
- Moisture adsorbed by wheel and heat is released
- Desiccant becomes saturated and must be dried (reactivated)

Reactivation of Desiccant

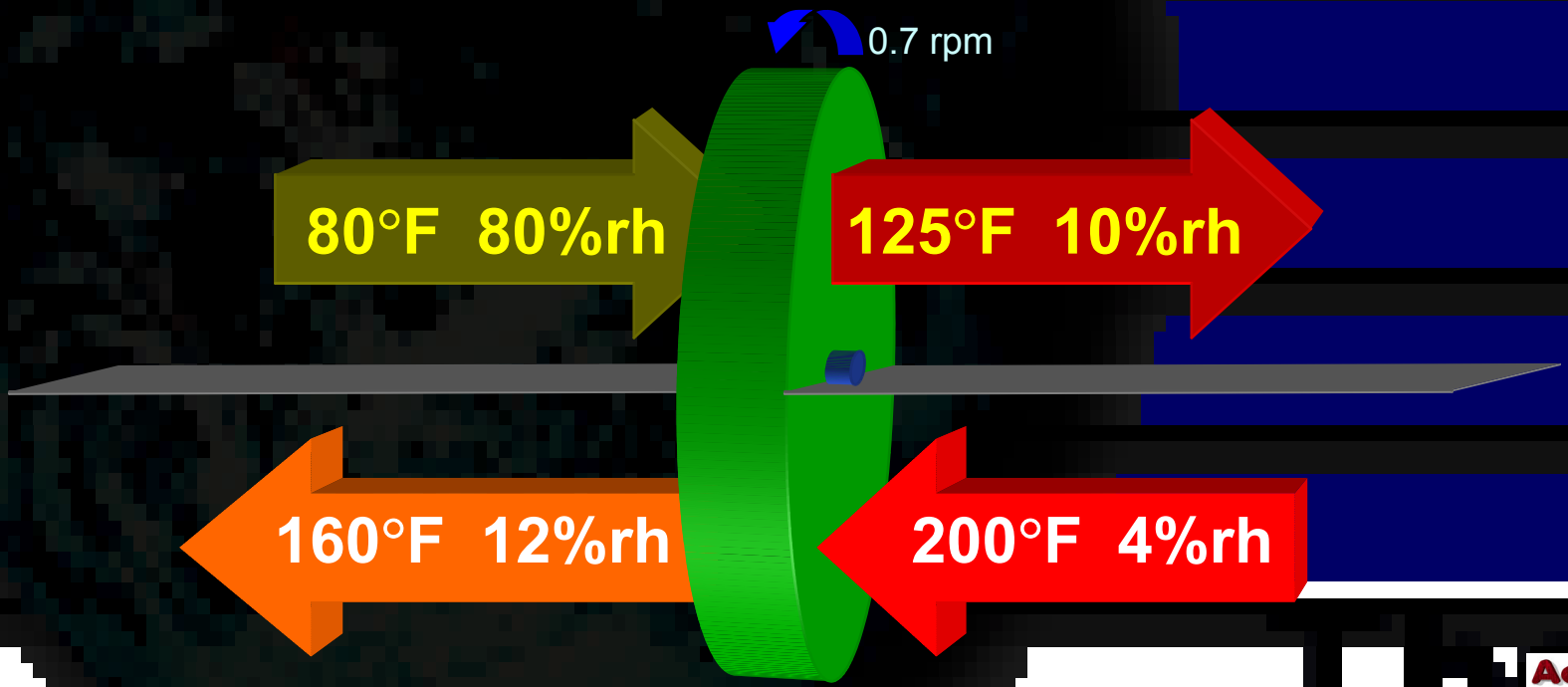
- Amount of moisture collected depends on the relative humidity and the saturation level
- Silica Gel holds 40% of its weight at 80% rh
- Reactivates to 5% of its weight at 4%rh





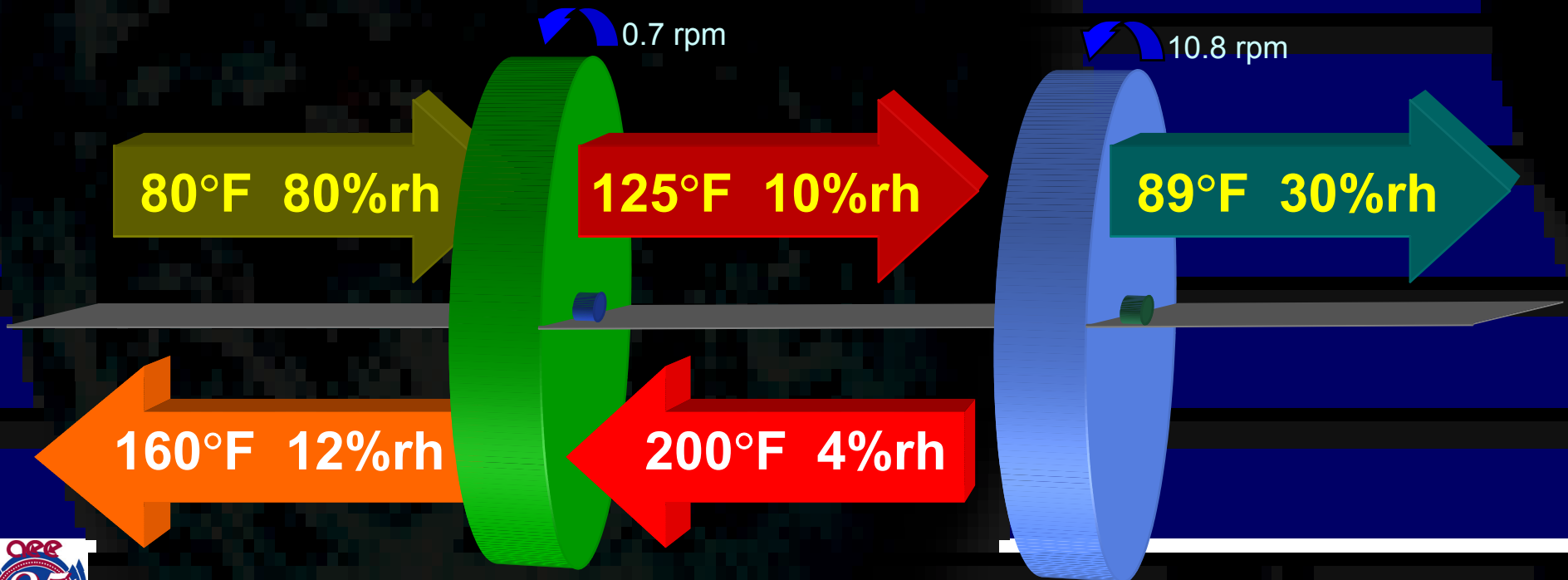
Reactivation Process

- Heat is released as moisture is adsorbed by wheel
- Ventilation air temperature rises from 80F to 125F
- Wheel rotates to reactivation side of unit
- Very dry air at 4%rh picks up collected moisture



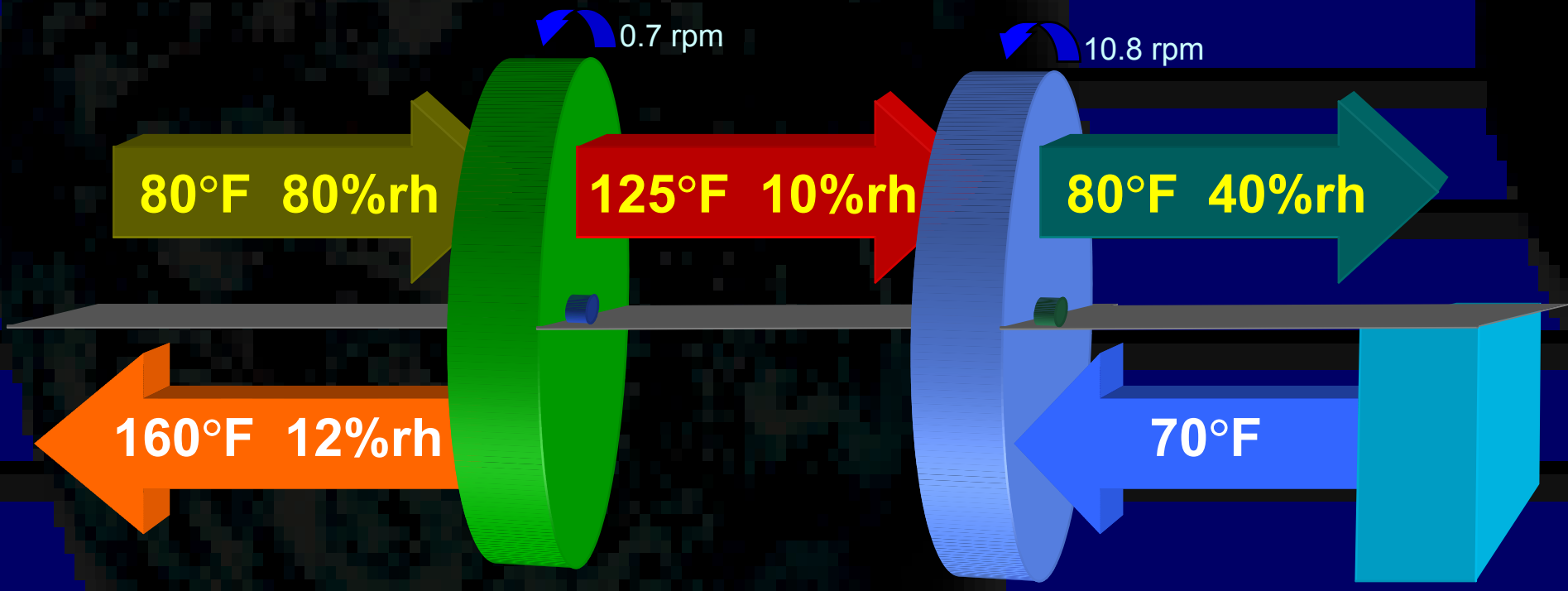
Cooling the Ventilation Air

- Desiccant converts latent heat into sensible heat
- Ventilation air is cooled by Heat Exchange wheel
- Wheel transfers heat from ventilation air to preheat

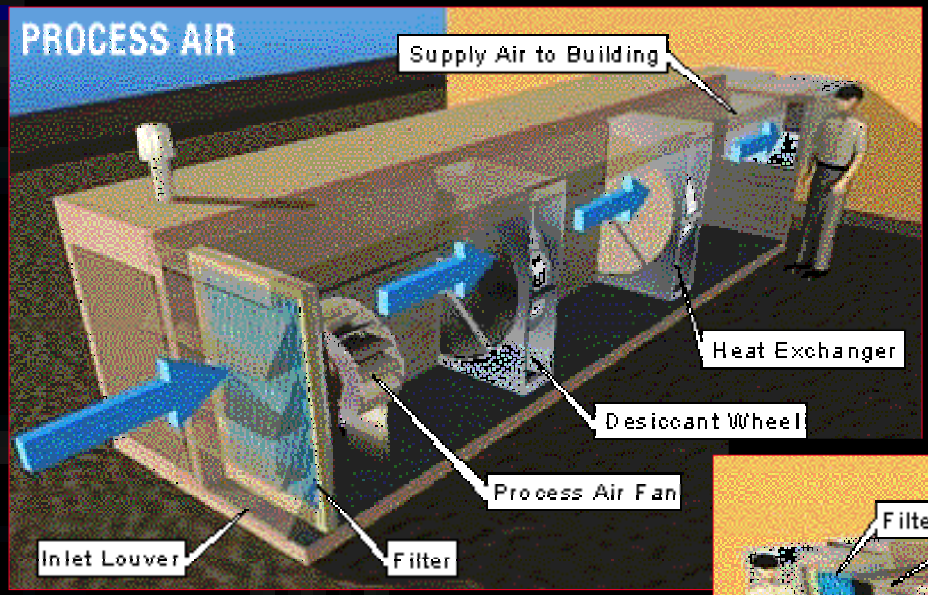


Evaporative Cooling

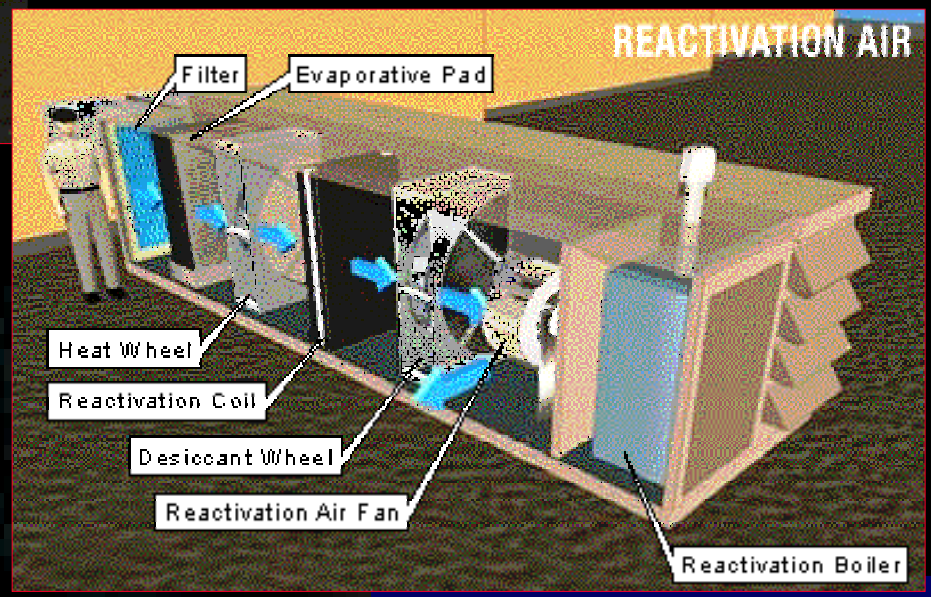
- Evaporative cooler increases heat wheel effect
- Ventilation air is less humid at same temperature
- Field unit rarely performed this well



Layout of unit



Supply Air Flow
Design: 4400 cfm
TAB report: 4166 cfm
Measured: 5470 cfm
0.2 cfm per square foot
1.3 air changes per hour



Reactivation Air Flow
Design: 4400 cfm
TAB report: 4333 cfm
Measured: 5255 cfm
3180 cfm outside air
2075 cfm exhaust air

As installed

- Natural gas 5.2 cfm
- (2) 5 hp fans
- 1.5 and 0.1 hp drives
- 5-ton DX post-cool
- 350 MBH 180°F Boiler
- 26 gpm hot water
- 77”-diameter wheels

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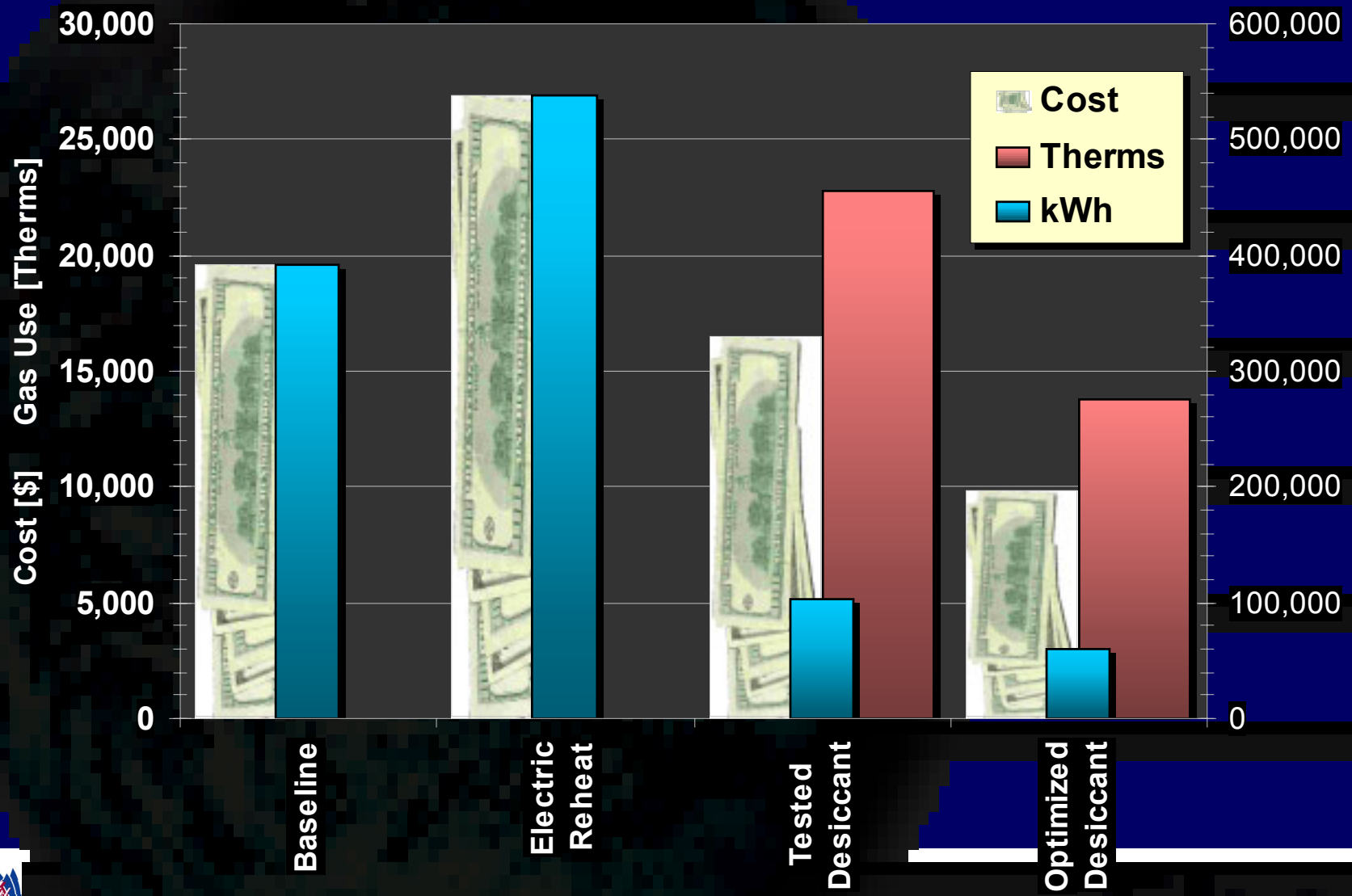
Overall Results

- ***Energy Efficiency***
  - Manufacturer's peak load rating: 0.73 COP
  - Measured peak load rating: 0.83 COP
  - Measured average: 0.53 COP
- ***Cooling Capacity***
  - 19% less dehumidification than rated
  - 155 MBH measured versus 248 MBH rated
- ***Heat Input***
  - 12% less than manufacturer's rating

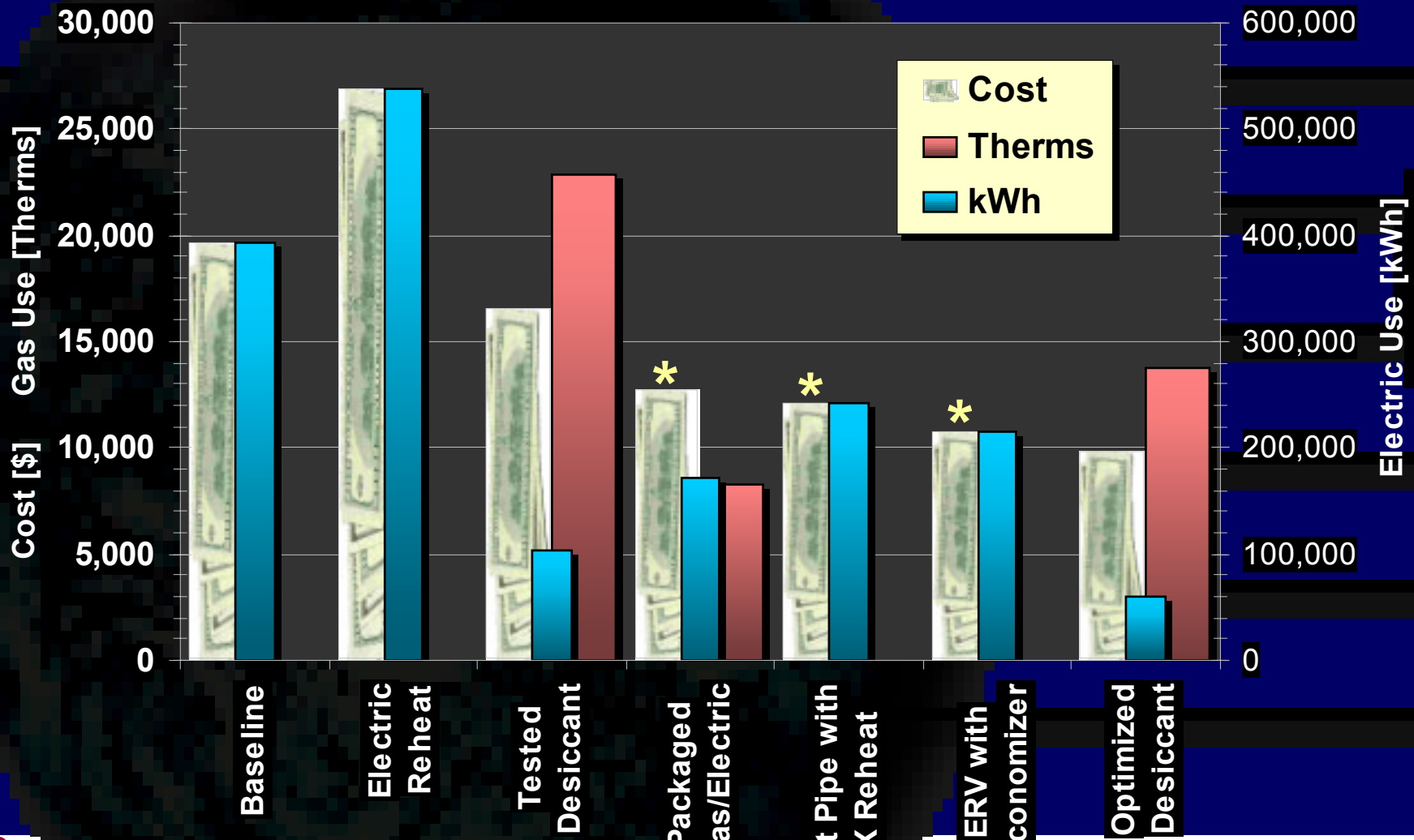
Lessons Learned

- Over time, the unit delivered less cooling and dehumidification than rated
- Unit consumes less energy than rated, but considerably more than optimal
- Efficiency rating at design conditions over estimates seasonal performance
- Efficiency decreases at cooler/humid ambient, opposite to DX equipment

Equipment Comparison



... more Comparisons*



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MAIN POINTS

- Long term as-installed performance was less than expected in terms of both capacity and efficiency.
- The decline in performance with decreasing sensible load – when dehumidification is critical – is more severe than was expected.
- Engineered improvements to the design and installation of a typical desiccant unit could reduce operating cost by 45%.
- Field monitoring and computer analysis of HVAC equipment performance can reveal many cost effective energy saving measures.