EEBA
Energy & Environmental Building Association ™

SUNBELT BUILDERS SHOW

Building Solutions Conference

Gaylord Texan Resort & Convention Center

October 20-23, 2004 - Dallas, Texas

# *Ventilation in Humid Climates: Data from Field Experiments*


Neil Moyer

FLORIDA SOLAR ENERGY CENTER

A Research Institute of the University of Central Florida

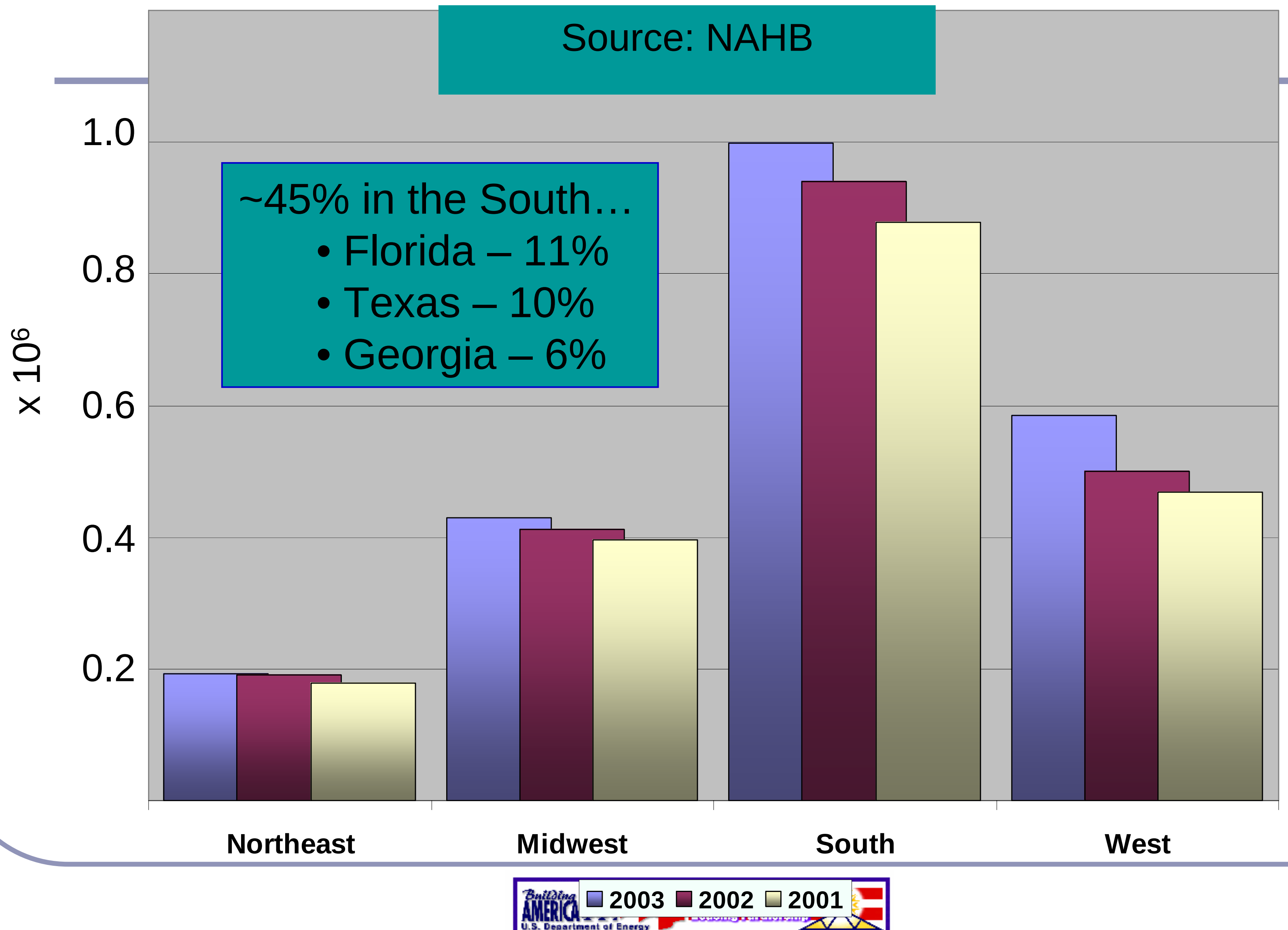

Building America U.S. Department of Energy

Industrialized Housing Partnership

FSEC

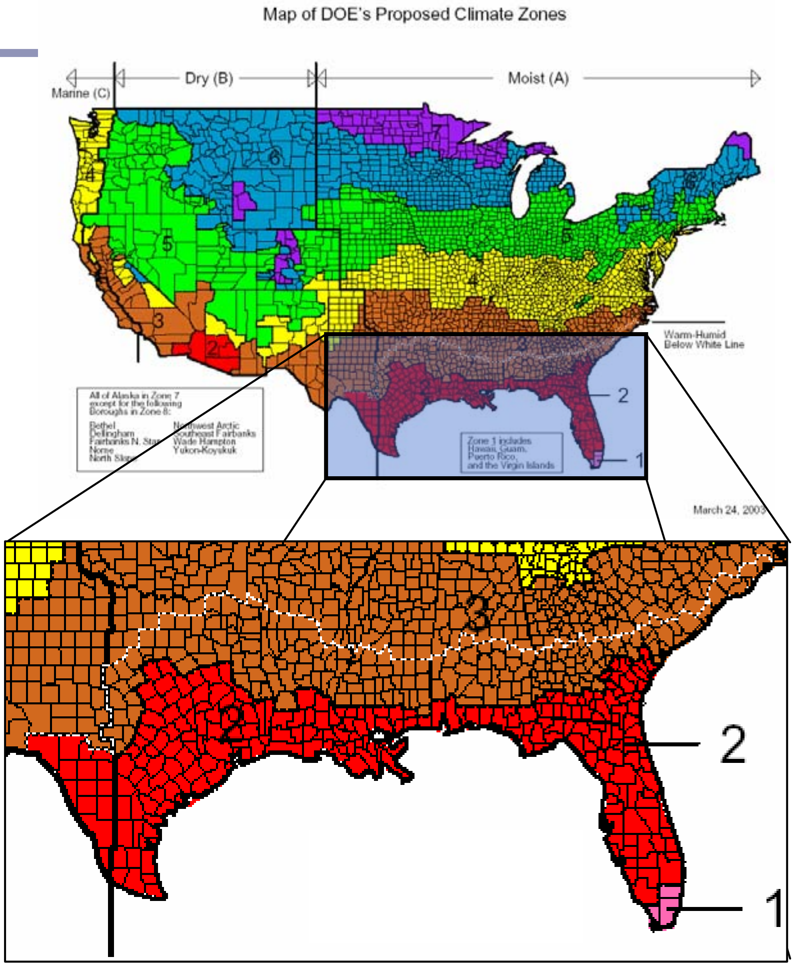
Building America U.S. Department of Energy Industrialized Housing Partnership

# Yearly Housing Starts Past 3 Years



# Hot, Humid Climate Defined

- Receives 20+ inches of annual precipitation and where one or both of the following occur:
  - A 67+°F  wet bulb temperature for 3,000+ hours during the warmest six consecutive months of the year; or
  - A 73+°F wet bulb temperature for 1,500+ hours during the warmest six consecutive months of the year.
- On the new DOE climate map, it is zones 1A and 2A and the portion of 3A below the white "warm-humid" line.



# Typical moisture loads

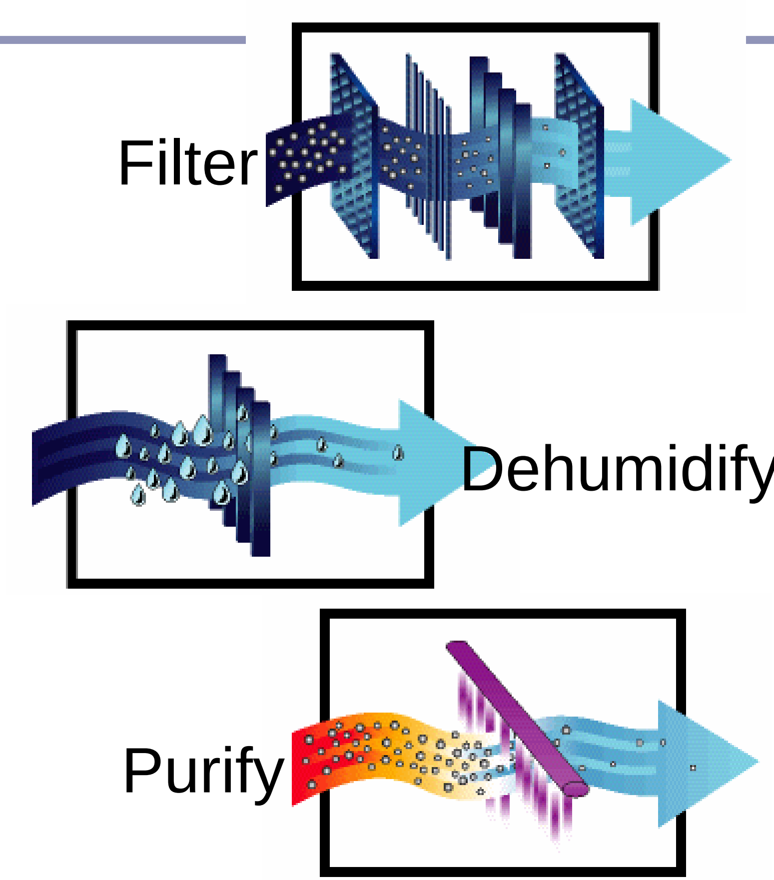
- 50 cfm of outside air
  ~ 1.7 lbs/hour
- Four people
  ~ 1 lb/hour
- Structural load
  ~ 1 lb/hour
- Total 3.7 lbs/hour or
  ~ 88 lbs/day

# Ventilation

The purpose of a residential ventilation system is to control odors and contaminants and indoor levels of moisture. These goals must be achieved without causing discomfort to the occupants, without unduly increasing the operating cost of the house, and without adversely affecting the building envelope or the operation of other mechanical systems.

# Ventilation

- We take about 20,000 breaths everyday & breathe in up to 200 million particles.
- Improve IAQ
  - Remove sources
  - Ventilate



# Manufactured Housing Lab and Training Facility

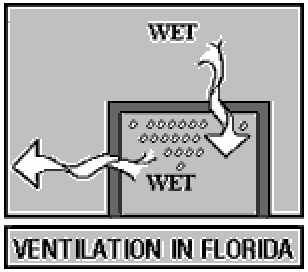
Building AMERICA U.S. Department of Energy Industrialized Housing Partnership

# MHLab Features

- 1600 ft2 — 3Bedroom/2Bath HUD-code home
- Energy Star compliant – HERS 88.3
- Two separate HVAC (properly sized) and tight duct systems
  - Package HVAC system – ducts in attic
  - Split HVAC system – ducts in floor
- Computer controlled occupancy simulation
- Automated data collection
- Solar ready roof trusses
- Central vacuum cleaner
- Gossamer ceiling fans

# Ventilation Strategies 2003

- **None**
  - June 3 – June 12
- **Spot Exhaust**
  - May 16 – June 1
- **50 cfm OA to AHU coil**
  - Tstat control - operates w/ ahu
  - June 17 – June 29
- **50 cfm OA to Dehumidifier**
  - Tstat control - operates w/ ahu
  - July 3 – July 14
- **50 cfm OA to AHU coil**
  - Fan cycler control 20 off/10 on
  - July 16 – July 30
- **Balanced ERV (R1)**
  - Cross flow fixed-plate enthalpic heat exchanger w/proprietary resin-media composite
  - August 1 – August 13
- **Balanced ERV (R2)**
  - Patented Rotary Random Matrix Polymer heat exchanger
  - August 15 – September 2
- **No vent – Package AC unit**
  - Attic ducts
  - September 3 – September 11
- **50 cfm OA to AHU coil**
  - Humidistat controlled AHU blower speed
  - September 13 – September 28
- **No Sims – AC only**
  - September 29 – December 30



# Basic Setup
# (common to all vent strategies)

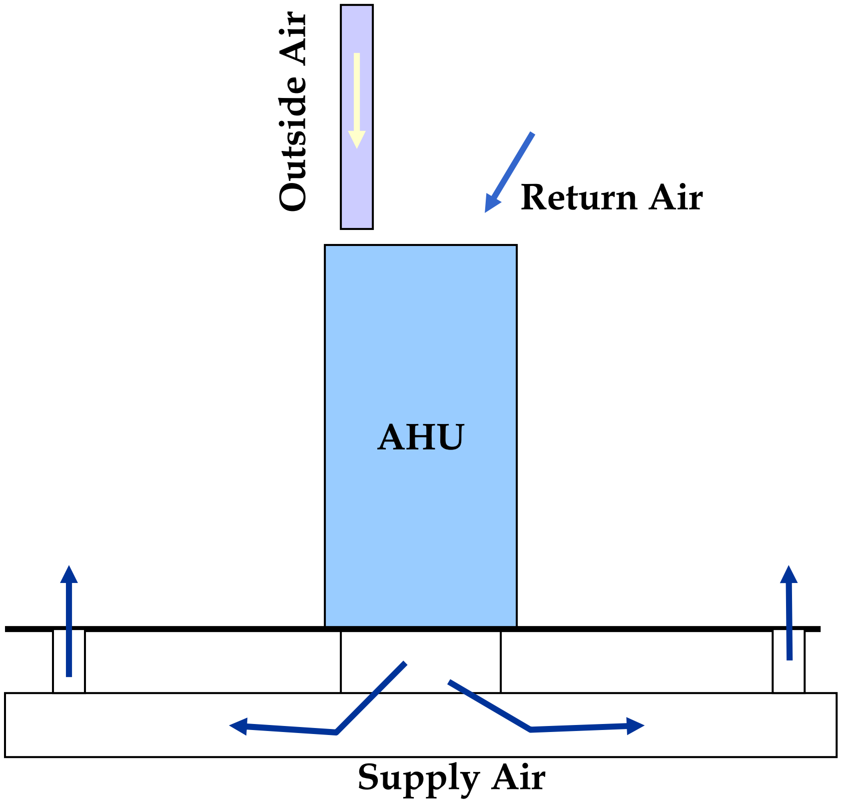
- Cooling setpoint = 75°F
  - Split system with floor ducts
  - SEER 12 equipment
- Simulated living
  - Cooking, showers, lights, dishwasher, occupants
  - Sensible added = 70 kBtu/day
  - Latent added = 20 lb $H_2O$/day

# Spot Exhaust May 16 – June 1

- Kitchen range exhaust ~100 cfm
- Bathroom exhaust ~50 cfm
- Quiet fans > $200
- Advantage
  - Removes excess moisture & pollutants at source
- Disadvantage
  - Does not provide ventilation air to desired spaces
  - Controls and quiet can be expensive

# OA to AHU June 17 – June 29

- 50 cfm outside air
- Ventilation air delivery based on air handler unit (ahu) run-time.
- Outside air delivered to ahu.
- Advantage
  - Lowest installed cost (~$200)
  - Simple operation – no occupant intervention required
- Disadvantage
  - Induction of outside air based on air handler fan operation which may result in over-venting during the day & under-venting at night.

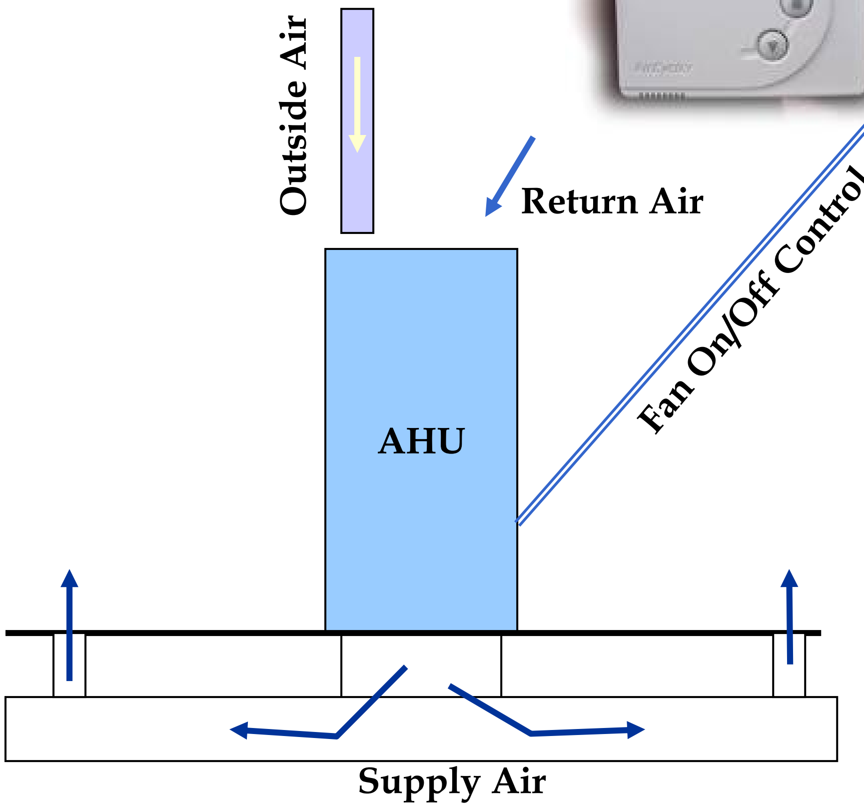


# OA to Dehumidifier July 3 – July 14

- Ventilation air delivery based on air handler unit (ahu) run-time
- 50 cfm outside air delivered to dehumidifier intake
- 40pint/day capacity
- ~ $400+ Installed cost (excludes OA ductwork)
- Advantage
  - Provides good humidity control
  - Dehumidifies both outside air and house air
- Disadvantage
  - Adds heat
  - Can be noisy
  - Longevity concerns
  - Operational costs
  - Hard to adjust for optimum setting

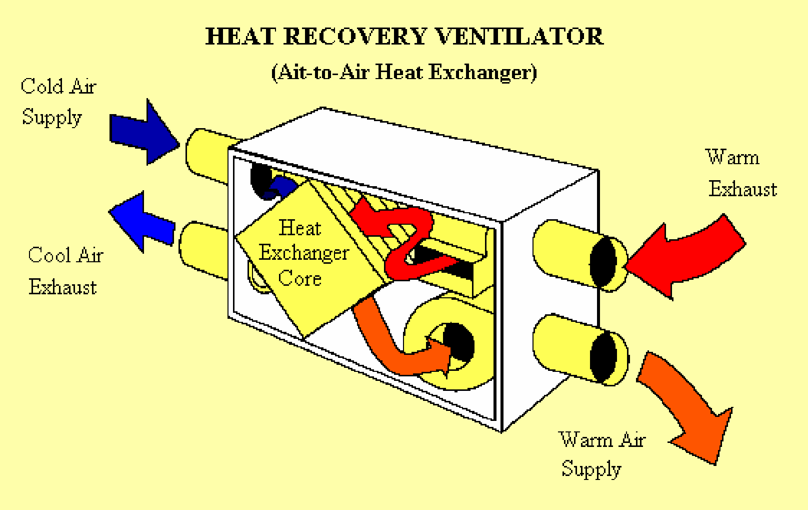
# AHU w/Aircyler™ July 16 – July 30

- Ventilation air delivery controlled by Aircycler™ controller
  - 20 minutes off / 10 minutes on
- 50 cfm outside air to ahu
- ~$200 (excludes OA ductwork)
- Advantage
  - Provides ventilation when cooling load satisfied
  - Periodic mixing of house air
- Disadvantage
  - When tend to increase interior relative humidity
  - Uses a large energy fan



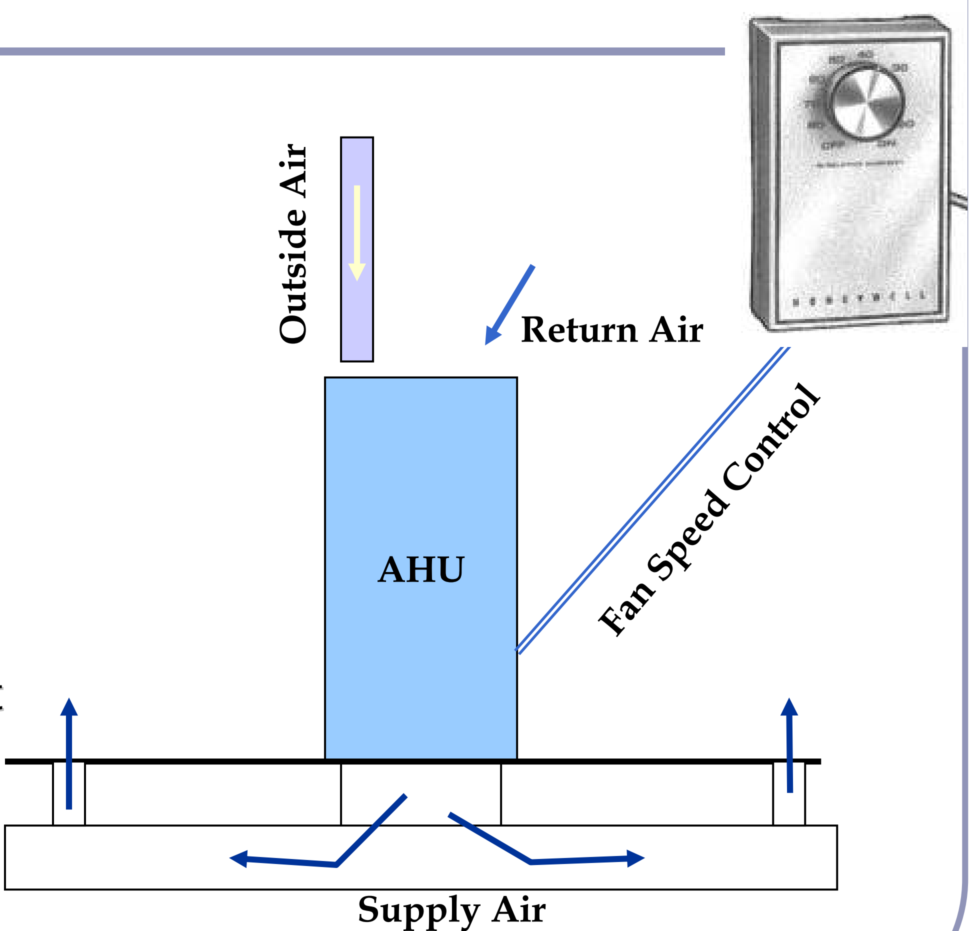
# Energy Recovery Ventilation

- Advantages
  - Operating cost
  - Reduces the ventilation load on the air conditioning system
  - Capable of balanced or slight positive pressure
  - Ventilation independent of heating/air conditioning system
- Disadvantages
  - Installed cost more than six times that of the stand-alone dehumidifiers
  - Humidity control performance is dependent on
    - Occupant numbers & behavior - internal moisture generation & use of spot ventilation
    - Crossing airstream vapor pressure difference



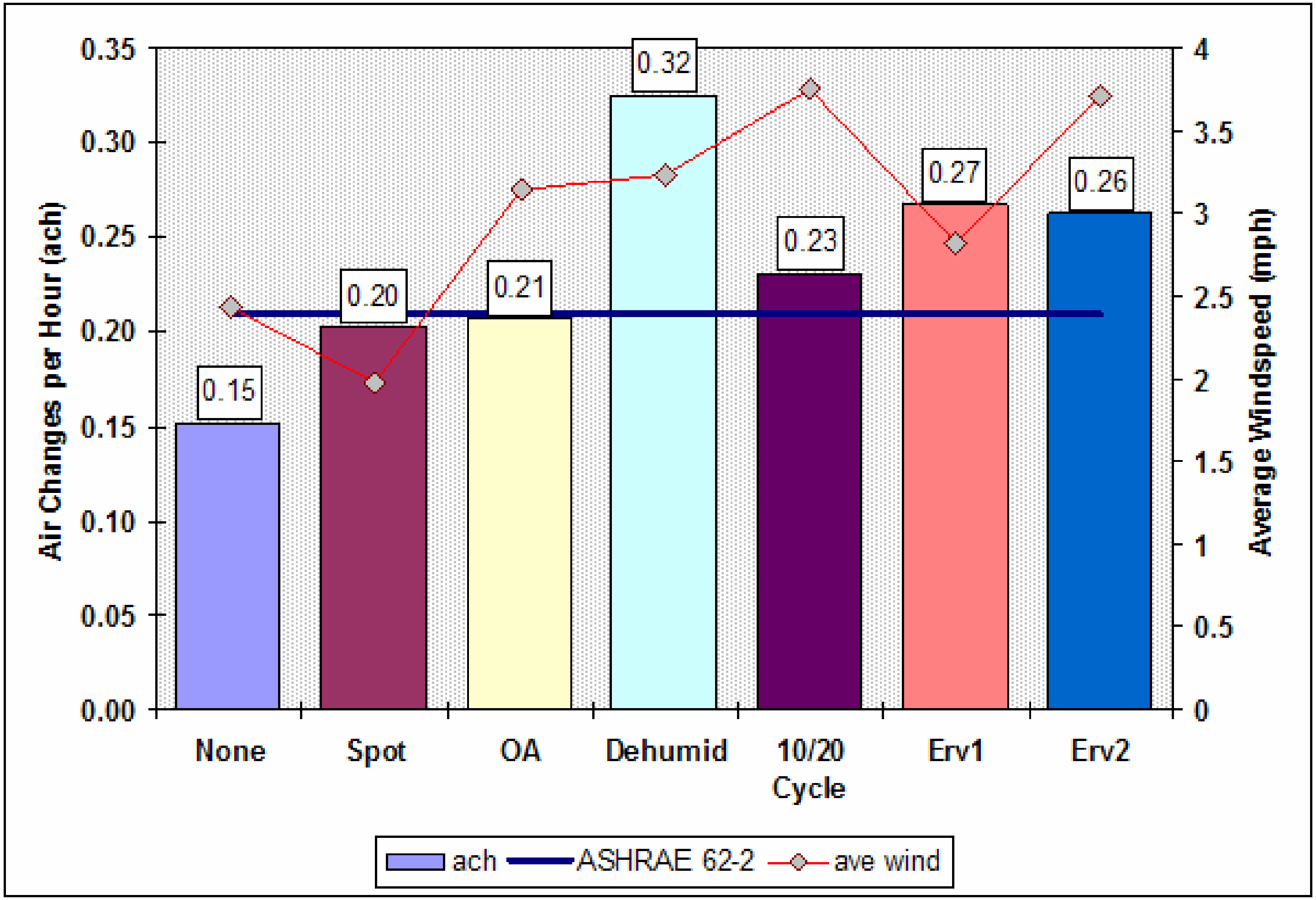
# Humidistat Controlled Fan

- Ventilation air delivery based on air handler unit (ahu) run-time
- 50 cfm outside air
- ~ $100+ Installed cost (excludes OA ductwork)
- Advantages
  - Automatically varies fan speed based on humidity
  - High speed for better sensible control
  - Low speed for enhanced latent removal
- Disadvantages
  - Reduces equipment efficiency



# Some Preliminary Results

# Measured Air Change Rates



# Relative Humidity Stats

**Table 2. Interior relative humidity statistics for various vent strategies**

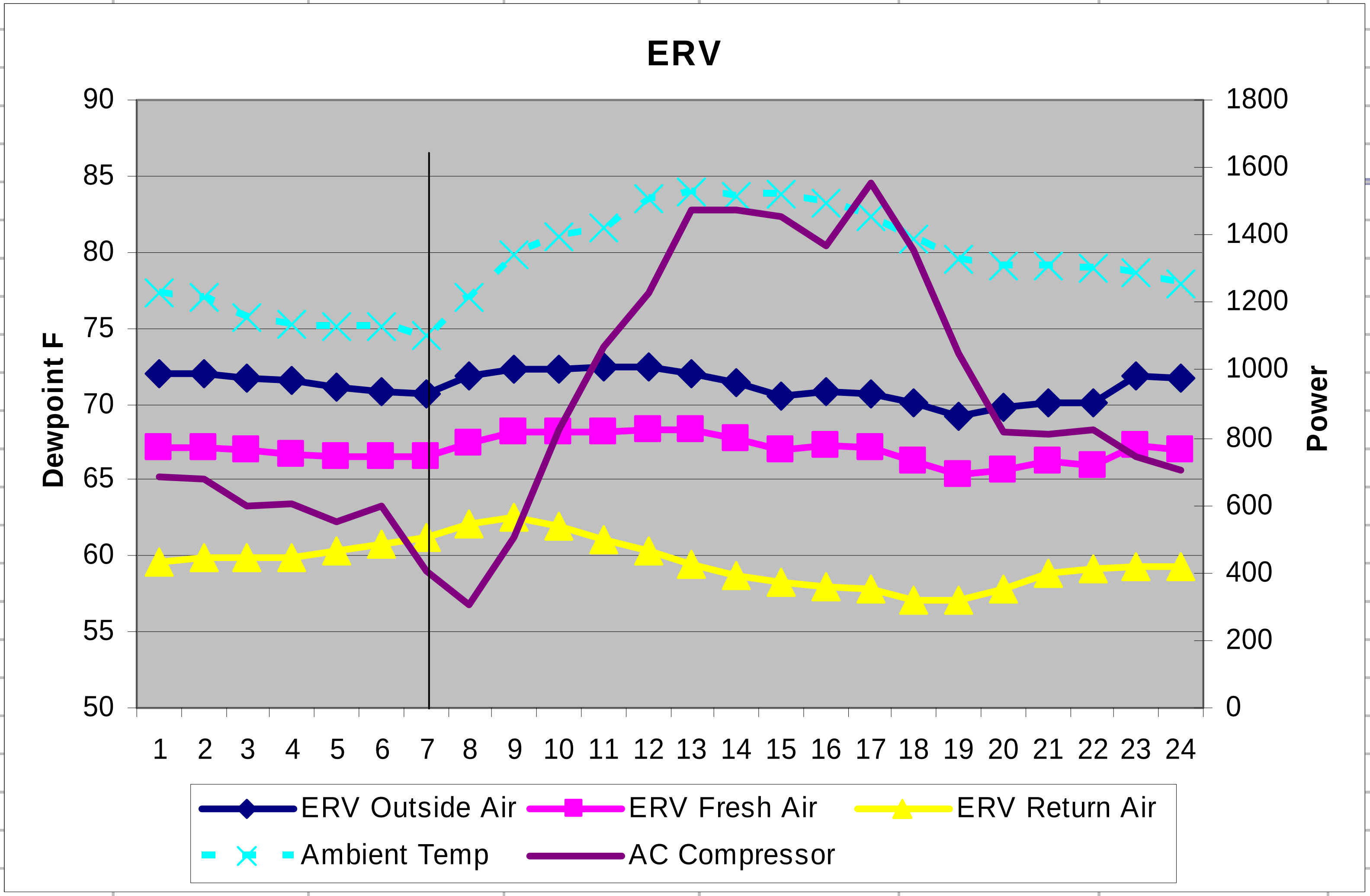
| | Case 1 None | Case 2 Spot | Case 3 OA | Case 4 Dehumid | Case 5 10/20 | Case 6 | | Case 7 Hstat |
|---|---|---|---|---|---|---|---|---|
| | | | | | | ERV1 | ERV2 | |
| Mean | 46.1 | 49.2 | 49.5 | 47.9 | 49.0 | 47.8 | 47.2 | 45.7 |
| Std Deviation | 1.272 | 1.471 | 1.673 | 0.845 | 1.231 | 2.194 | 2.108 | 3.07 |
| Range | 11.2 | 16.3 | 7.4 | 4.8 | 12.1 | 20.6 | 13.7 | 21.7 |
| Minimum | 42.1 | 38.8 | 45.8 | 46.2 | 46.3 | 44.2 | 39.3 | 39.7 |
| Maximum | 53.3 | 55.2 | 53.2 | 51.0 | 58.4 | 64.8 | 53.0 | 61.4 |

# ΔTemp & Power

**Table 3. Cooling and ventilation power (watts) usage as a function of temperature difference across the building envelope**

| ΔTemp (°F) | Case 1 None | Case 2 Spot | Case 3 OA | Case 4 Dehumid | Case 5 10/20 | Case 6 | | Case 7 Hstat |
|---|---|---|---|---|---|---|---|---|
| | | | | | | ERV1 | ERV2 | |
| -5 | 487 | 499 | 475 | 499 | 411 | 459 | 367 | 526 |
| 0 | 924 | 911 | 949 | 1046 | 863 | 915 | 880 | 1006 |
| 5 | 1361 | 1324 | 1424 | 1592 | 1315 | 1370 | 1393 | 1485 |
| 15 | 2236 | 2150 | 2372 | 2685 | 2219 | 2280 | 2418 | 2443 |

# Some new stuff




MHLab Oct 1 – Oct 10, 2004

# Condensation in Florida


Gainesville, Florida

# Effect of Outside Air on Interior Apartment Humidity in Florida

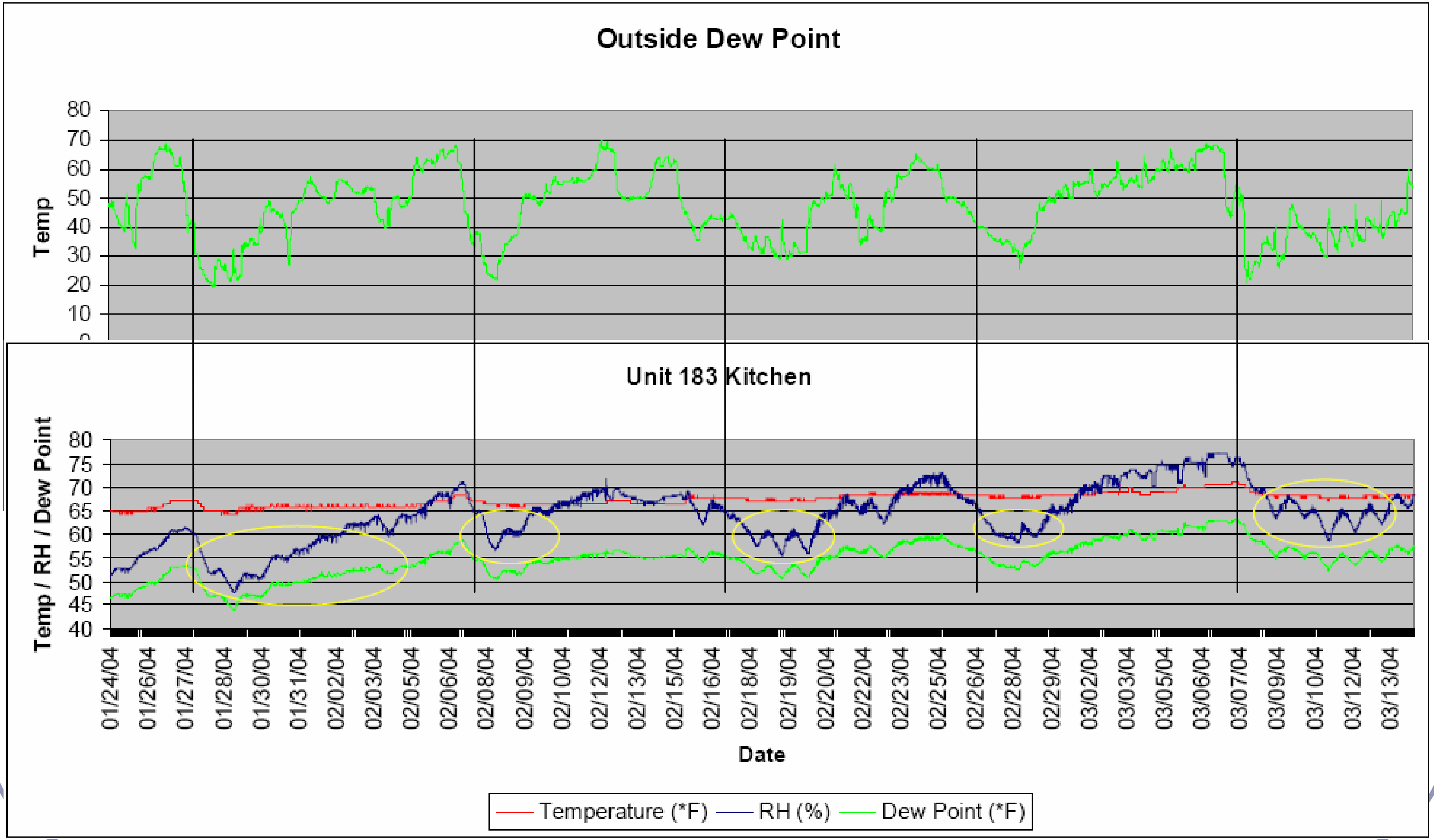
- Testing done in response to request by builder.
- Condensation on many of the lower windows in wintertime – especially North side.
- 2 unoccupied units supplied for testing.

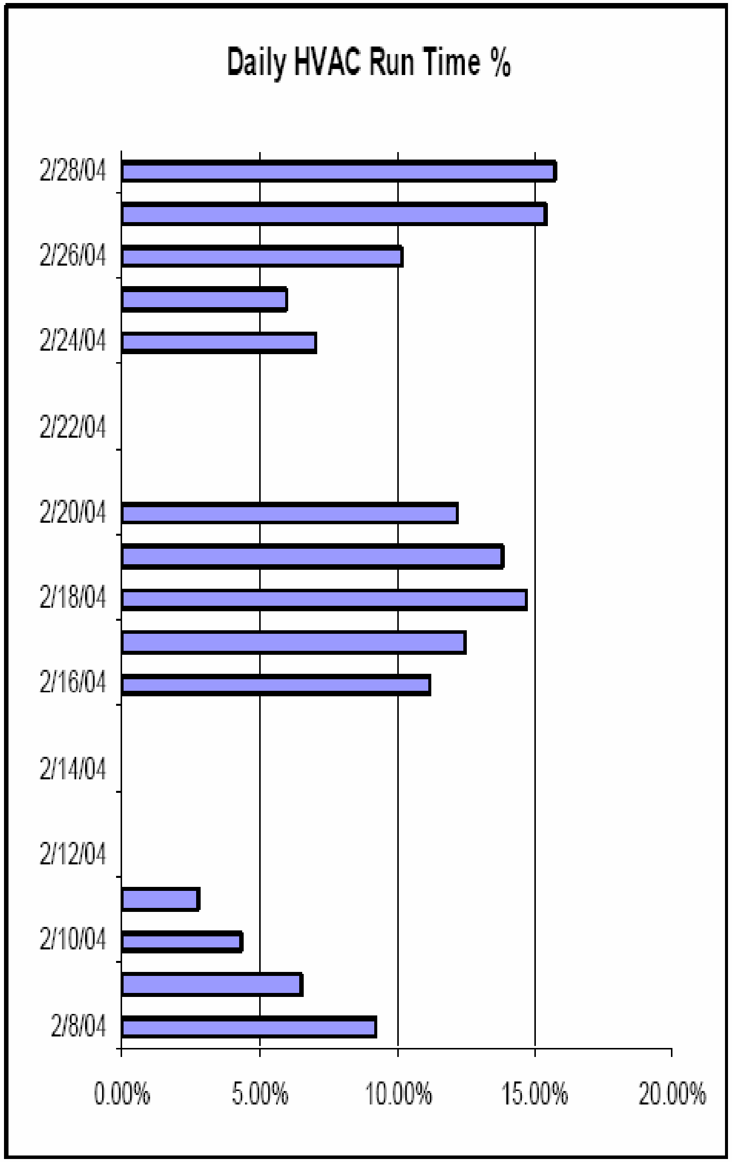
# AHU & Ventilation Duct

- 4 inch duct terminates in the return plenum of the air handler
- Approx 20 cfm when unit operates
- Thermostat set @ 70F
- ~ 1 gallon water added daily to simulate occupancy


03/02/2003

# Winter Results

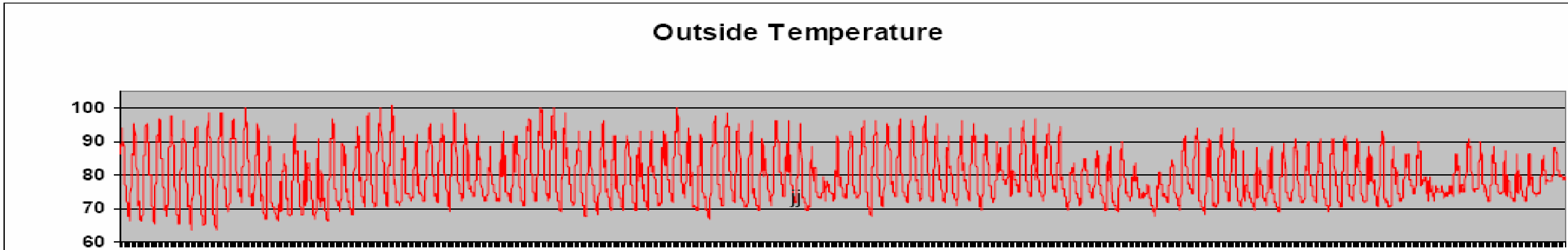


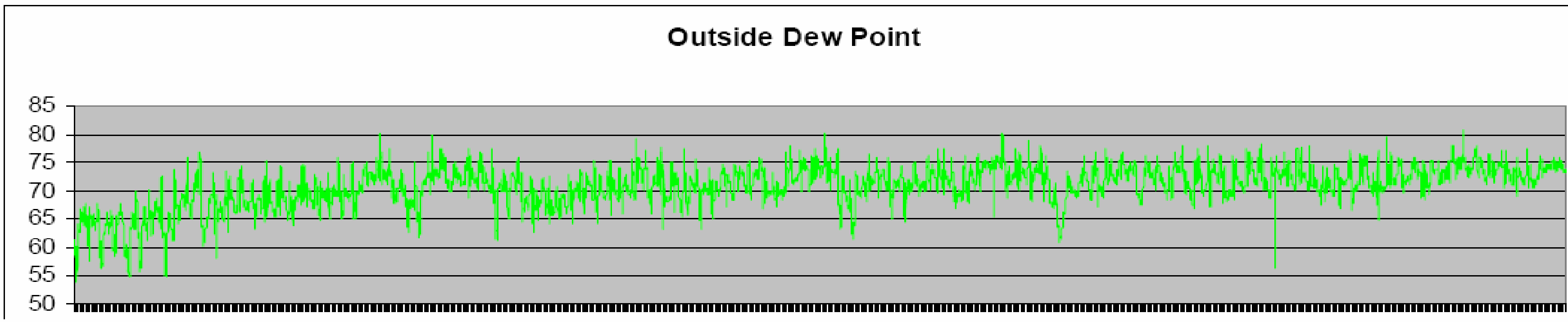


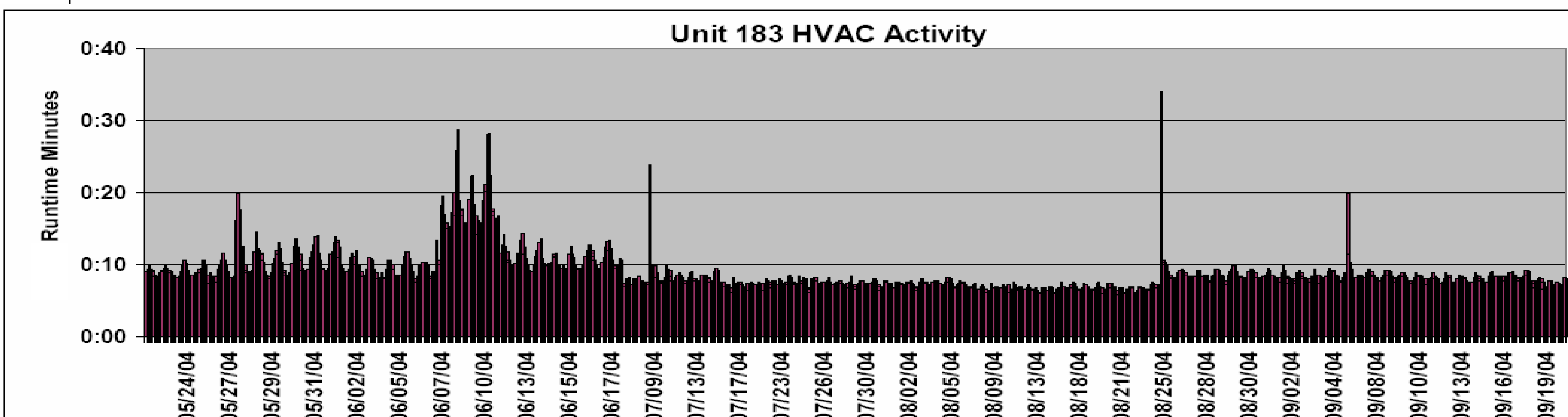

Daily HVAC run time as a percentage of a 24hour day

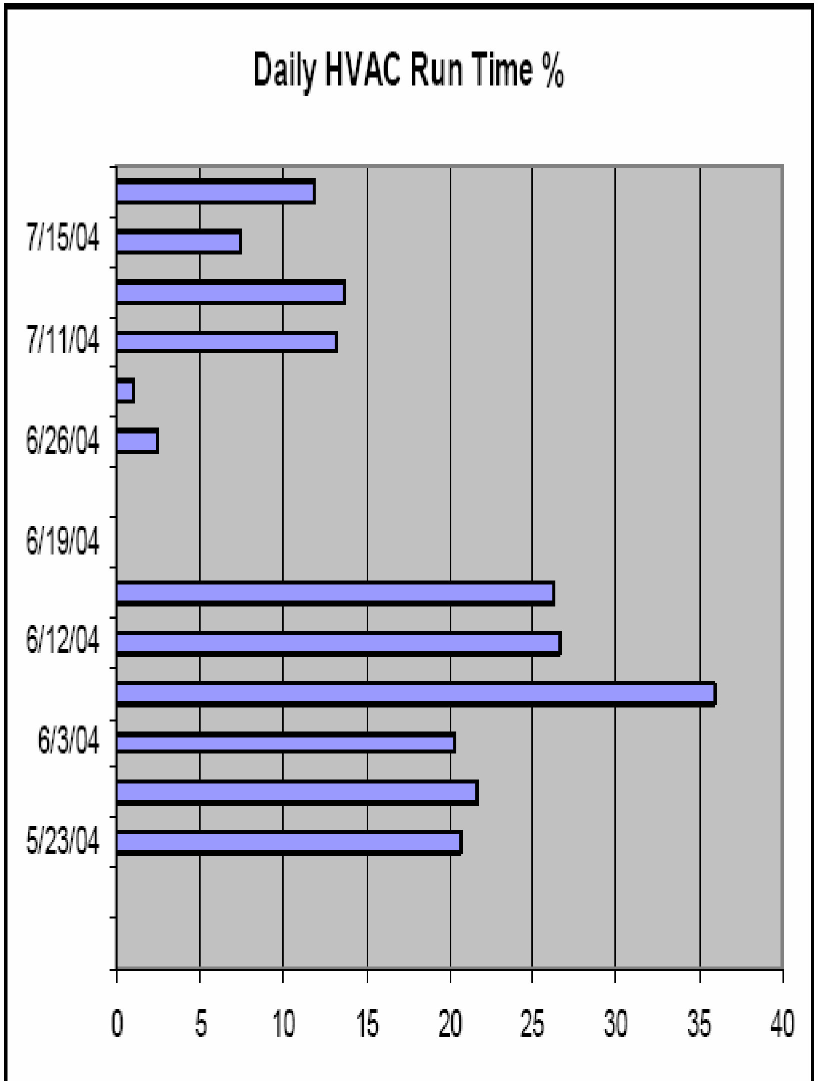
| Date | Run Time % | Run Time Duration hr:mm:ss | Daily RH Average |
|---|---|---|---|
| 2/8/2004 | 9.23% | 2:12:19 | 59.80 |
| 2/9/2004 | 6.51% | 1:31:42 | 63.13 |
| 2/10/2004 | 4.32% | 1:02:07 | 66.21 |
| 2/11/2004 | 2.77% | 0:37:31 | 68.28 |
| 2/16/2004 | 11.17% | 2:40:59 | 65.60 |
| 2/17/2004 | 12.50% | 2:59:33 | 64.14 |
| 2/18/2004 | 14.74% | 3:32:09 | 59.94 |
| 2/19/2004 | 13.86% | 3:19:09 | 59.06 |
| 2/20/2004 | 12.18% | 2:51:13 | 60.44 |
| 2/24/2004 | 7.06% | 1:10:24 | 71.31 |
| 2/25/2004 | 5.97% | 1:22:46 | 71.87 |
| 2/26/2004 | 10.20% | 2:22:26 | 67.54 |
| 2/27/2004 | 15.38% | 3:37:59 | 61.48 |
| 2/28/2004 | 15.76% | 2:50:40 | 60.69 |

# Summer Results



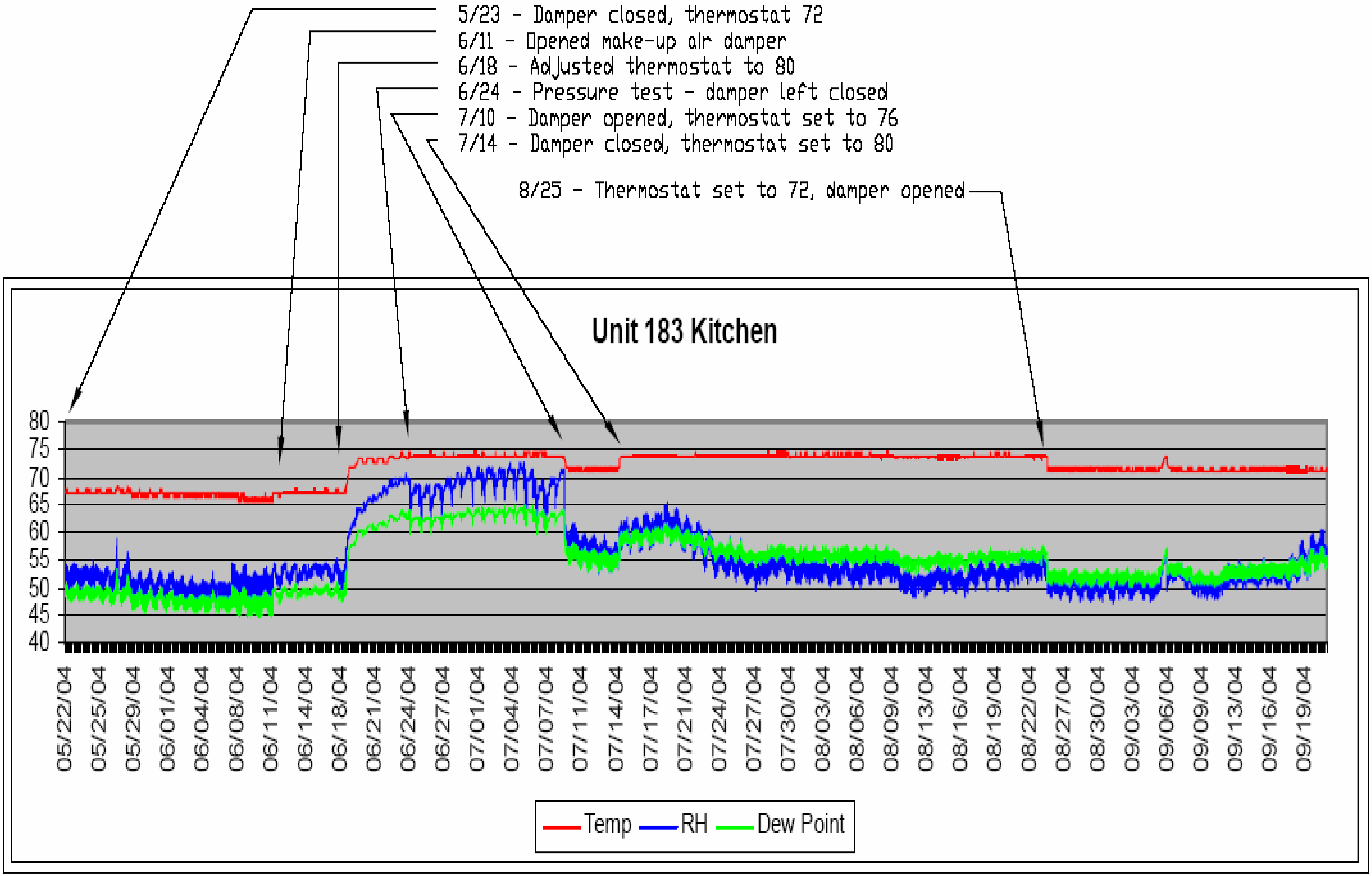






Daily HVAC run time as a percentage of a 24hour day

| Date | Run Time % | Run Time Duration hr:mm:ss | Daily RH Average |
|---|---|---|---|
| 5/23/2004 | 20.7 | 4:54:33 | 52.75 |
| 5/25/2004 | 21.7 | 5:09:49 | 52.68 |
| 6/3/2004 | 20.32 | 4:48:37 | 49.82 |
| 6/9/2004 | 35.87 | 8:32:36 | 50.76 |
| 6/12/2004 | 26.60 | 6:22:44 | 52.98 |
| 6/17/2004 | 26.32 | 6:21:12 | 53.26 |
| 6/19/2004 | 0 | 0 | 63.21 |
| 6/22/2004 | 0 | 0 | 68.67 |
| 6/26/2004 | 2.49 | 0:37:10 | 67.40 |
| 7/08/2004 | 1.07 | 0:14:45 | 69.33 |
| 7/11/2004 | 13.21 | 3:15:03 | 57.85 |
| 7/13/2004 | 13.73 | 3:13:15 | 56.90 |
| 7/15/2004 | 7.46 | 1:47:56 | 60.21 |
| 7/26/2004 | 11.89 | 2:55:34 | 54.91 |



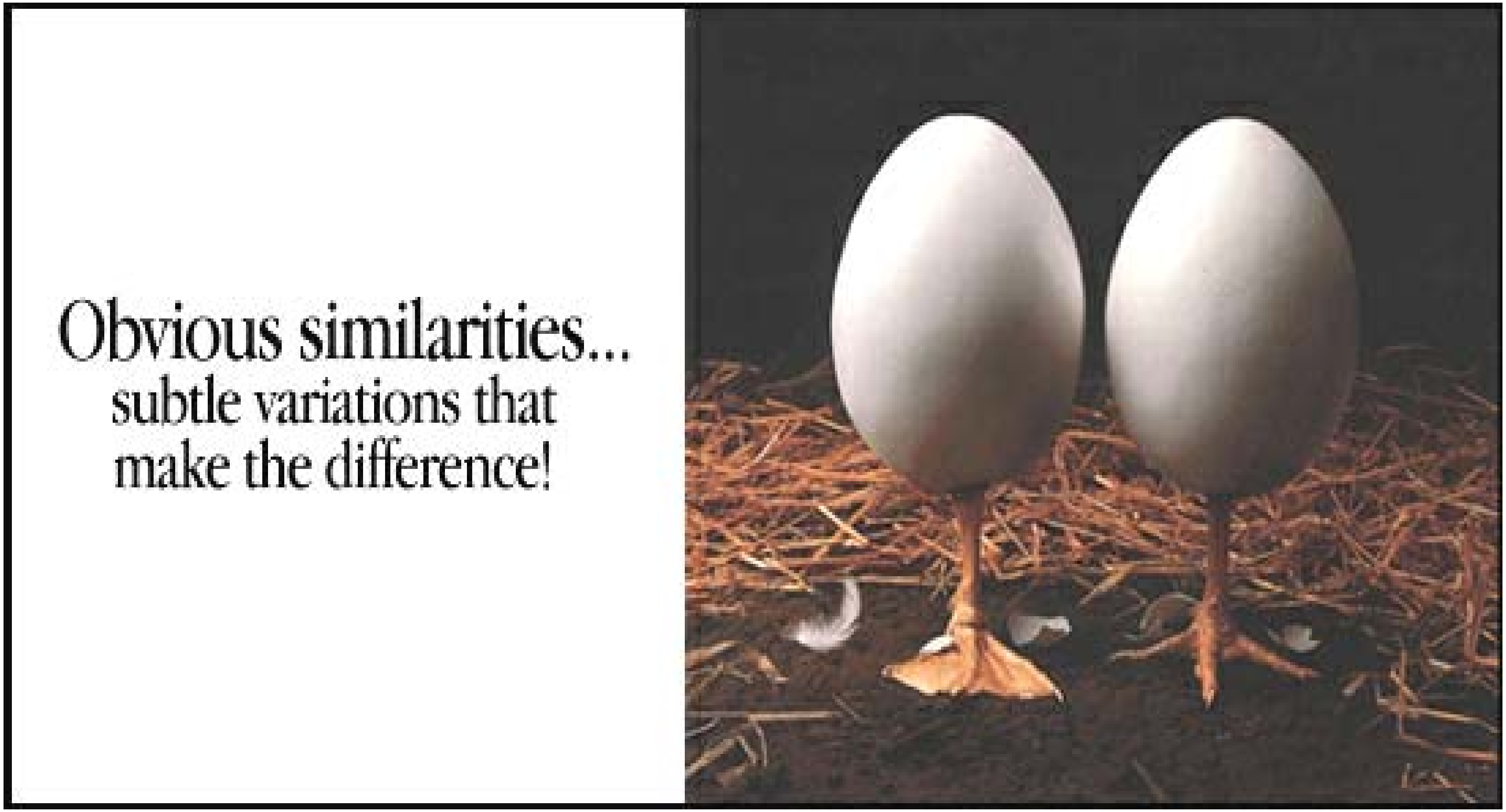
5/23 - Damper closed, thermostat 72
6/11 - Opened make-up air damper
6/18 - Adjusted thermostat to 80
6/24 - Pressure test - damper left closed
7/10 - Damper opened, thermostat set to 76
7/14 - Damper closed, thermostat set to 80
8/25 - Thermostat set to 72, damper opened
Unit 183 Kitchen
80
75
70
65
60
55
50
45
40
05/22/04
05/25/04
05/29/04
06/01/04
06/04/04
06/08/04
06/11/04
06/14/04
06/18/04
06/21/04
06/24/04
06/27/04
07/01/04
07/04/04
07/07/04
07/11/04
07/14/04
07/17/04
07/21/04
07/24/04
07/27/04
07/30/04
08/03/04
08/06/04
08/09/04
08/13/04
08/16/04
08/19/04
08/22/04
08/27/04
08/30/04
09/03/04
09/06/04
09/09/04
09/13/04
09/16/04
09/19/04
Temp
RH
Dew Point

# Recommendations

1. Bathroom vent fans should be on the same switch circuit as the bathroom light.
2. All NORTH SIDE apartments BELOW THE TOP FLOOR should be pre-configured for dehumidifier installation.
3. Average RH levels during both winter and summer periods were slightly higher than recommended. Supplemental dehumidification be installed in order to obtain an average of 55% or lower interior RH.
4. Kitchen range vent hoods should be vented to outdoors.
5. Air Conditioning units should be "right-sized" to better condition the space. TDR's (Time Delay Relays) if present should be disabled to prevent the re-evaporation of moisture that has condensed on the evaporator coils.
6. The vented attic over the entry foyers should be separated from the floor cavity with an air barrier and the resulting area insulated.
7. The seam at the point were the boots penetrate the ceiling should be sealed prior to the installation of the supply register. Mastic has proven effective.
8. Bedrooms should have appropriately sized return air pathways installed to insure proper pressurization WRT the living area and main return.
9. The humidity controllers used in some dehumidifiers may be quite inaccurate and have a large dead band.. Proper testing/calibration of the humidistat is essential in a reheat system and also important for stand alone dehumidification.
10. Occupant education

www.fsec.ucf.edu

# Thank You


Obvious similarities...
subtle variations that
make the difference!