Moisture and Housing Research at USDA - FPL

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Areas

- Moisture-related properties of wood products
- Moisture accumulation in light-frame walls: Effects of
  - air leakage
  - indoor moisture loads
  - wall design

This presentation concerns

<u>Research/Demonstration [Demonstration/Research] House</u>

Industry funded - - show that if there aren't stupid construction errors, contemporary wood-framed houses are durable

House characteristics

- Contemporary design
  - has some features that are less than ideal from a water-management perspective
- AWWF (CCA-treated lumber and plywood)
- 2x6 walls (OSB-sheathed & cellulose-insulated)
  - Damp spray - no interior vapor retarder (for the most part)
- Garage walls and ceiling insulated (and drywalled)
- Various cladding systems
- Sealed combustion gas furnace
- Energy recovery ventilator
  - Exhaust air from bathrooms: makeup air into return ducting

House air-tightness/leakiness

- ACH50 of 4.3 (common mode testing: garage door(s) closed – both overhead and house/garage passage)
  - Roughly equivalent to 60% of the houses (that we've tested) constructed in the 537XX Zip-code since 1990
  - ACH50 of 4.3 = 1300 cfm50, of which 350 cfm was directly thru envelope and 950 cfm was thru series-attached zones

Site conditions

- Reasonably dry
  - (flooding potential aside from backed-up gutter - nil)
- Cold climate (7400 HDD - - historically)
  - Oct 2001 - May 2002: 6214 HDD
  - Sept 2002 - May 2003: 7471 HDD
  - Sept 2003 - May 2004: 6971 HDD
  - Sept 2004 - May 2005: 6545 HDD
  - Sept 2005 – Apr 2006: 6229 HDD
- Winters not as cold as they used to be, but still > 5400 HDD - - - the DOE Building America definition of a cold climate

Construction history

- Damp spray cellulose installed 6/19/01
  - Building weather-tight, (roof functional, windows in, and WRB over wall sheathing, but cladding not yet installed)
- Drywalled 6/29 – 7/1/01
- Painted (interior latex flat) late August '01
- Spray moisture had dissipated by time of painting
- Tyvek WRB (very vapor permeable):
  - Various claddings installed late July to late Sept '01
- Gutter installation late Sept. '01
- Landscape grading Oct. '01

Operational history preview

- Eight instrumented wall cavities (above grade)
- Instrumentation in clear-field walls
  - – Garage had largest expanse of clear-field wall
- Garage sidewall was the only one with stucco cladding
- Thus for all heating seasons, garage was conditioned like interior space (and wasn't isolated from the house during AC seasons)

Operational history: by heating season

- 2001/02: No humidification or (intentional) ERV
- 2002/03: No humidification or (intentional) ERV
- 2003/04: Design humidity (monthly set-points)
- 2004/05: Design humidity (monthly set-points)
- 2005/06: Garage isolated from house:
  - Garage: design humidity level (as before)
  - House design load (10 Liters/day release), and run ERV 20 minutes each hour
- Building AC'ed (75^{o} F setpoint) in summer
- May thru October: daily 15-minute public tour

Design humidity levels: (monthly setpoints)

- Based on calculation methodology of ASHRAE Draft Standard 160-P
  - Design value (above average loads)
  - Based on the following assumptions
    - Higher than average interior moisture sources (14.2 L/day)
    - Moderate in-use air-exchange ratio (0.2 ACH) (equivalent to 60 cfm for 18,200 ft^3 inter. vol. - - - coincidentally the vent rate recommended by ASHRAE Std. 62.2 for acceptable IAQ in a 2200 ft^2 3 BR home)
- 10^{th} percentile in terms of humidity level
  - For the aggregate existing housing stock, one house in ten will have higher winter indoor RH levels. For New houses, it's probably more like one in three?

The Interior RH Levels

- Oct: 66%
- Nov: 54%
- Dec: 45%
- Jan: 43%
- Feb: 43%
- Mar: 50%
- Apr: 59%
- Correspond with 8.2% -12.2% EMC (4% seasonal mc swing ignoring sorption hysteresis) - - - Nice for finish floors and furniture

The first two heating seasons

(no occupants, no humidification, 65^{o} F)

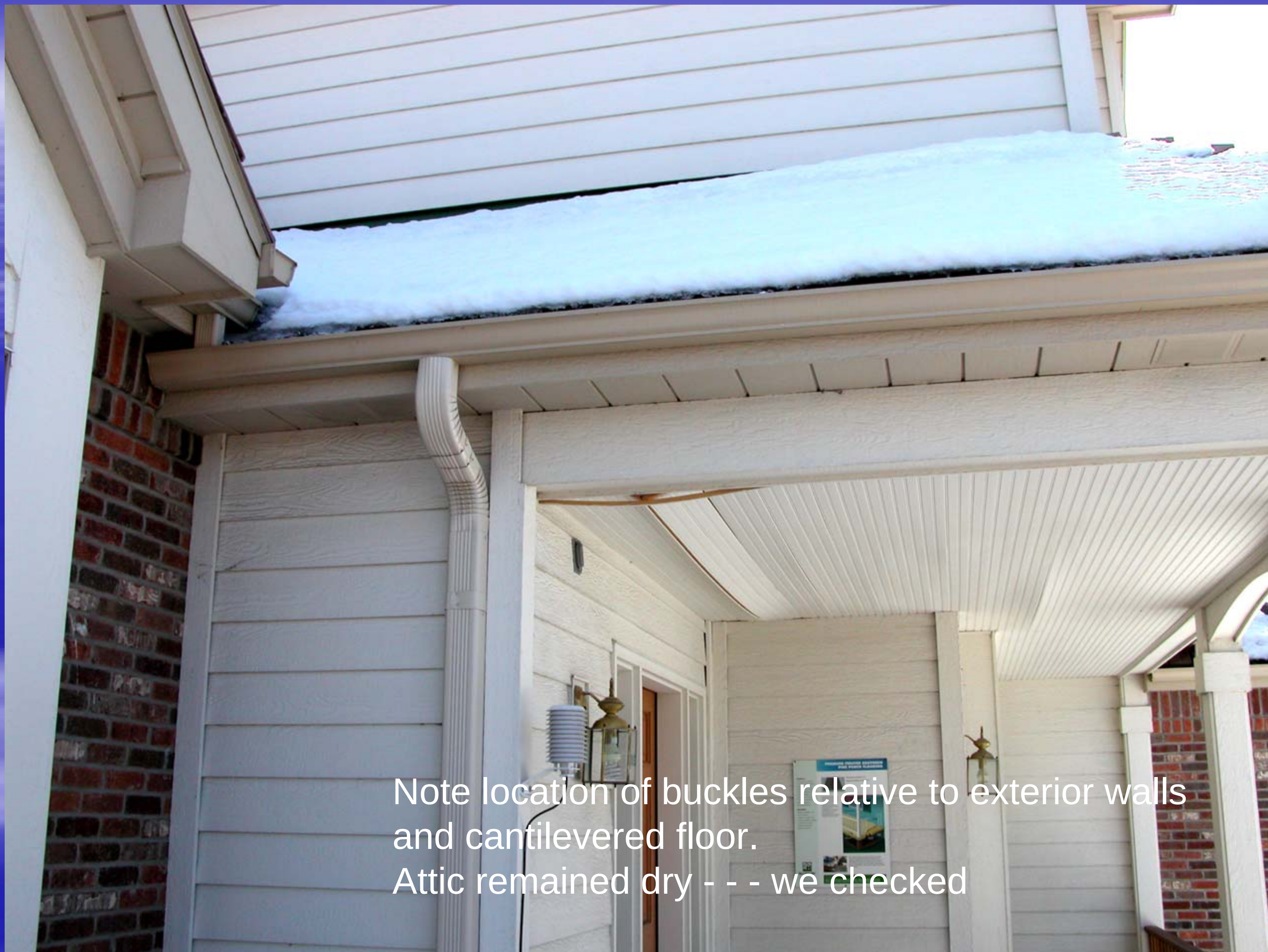
- Interior vapor pressures were at roughly 85% of those that would correspond with those at design temp/RH levels
  - Landscape grading and guttering in the construction sequence (H_2O in sump)
  - Sealed-combustion furnace (ACH probably < 0.2 when ERV isn't enabled)

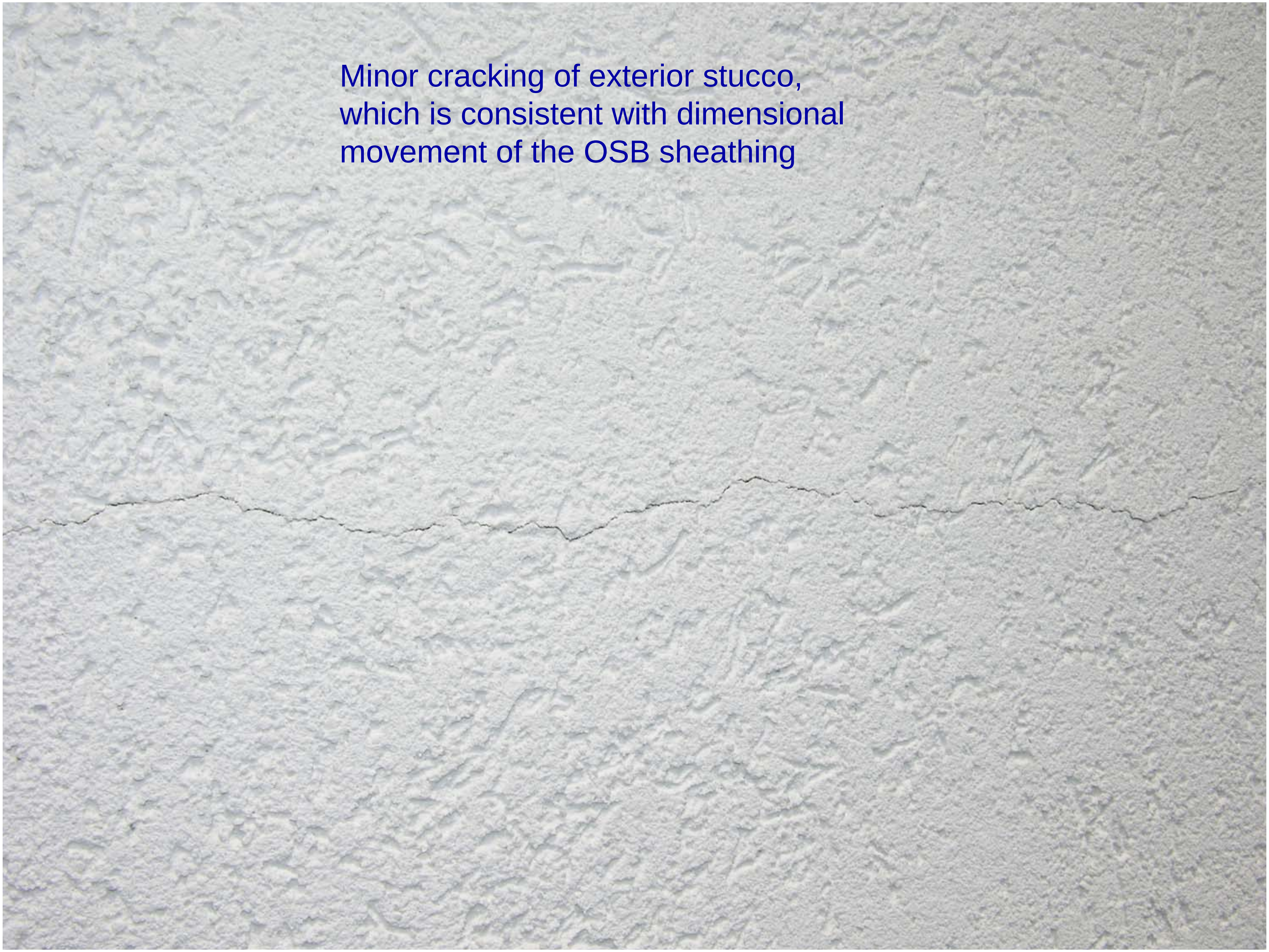
Heavy condensation on mediocre IGU's when outdoor temp fell below 10º F

But condensation only on glass - - -
No water on, or staining of, sash

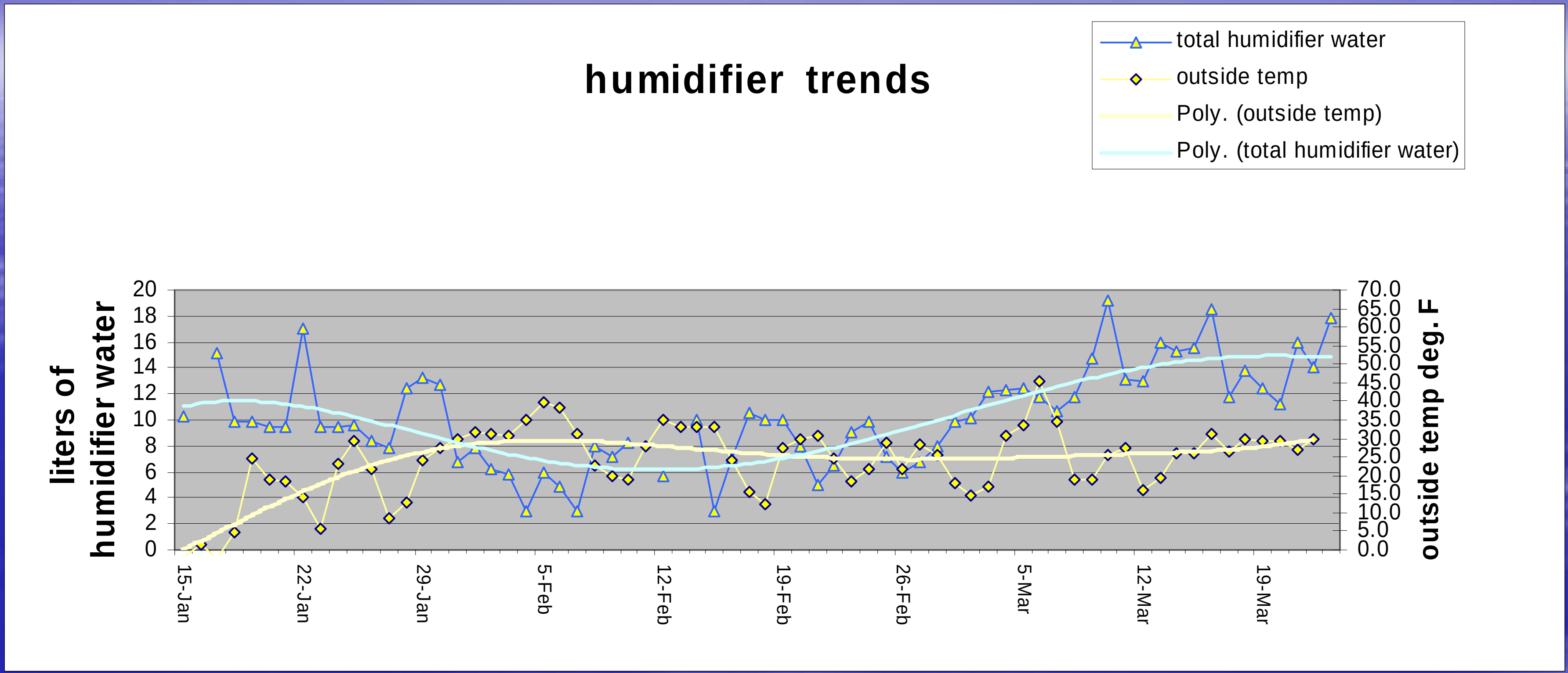
Minor condensation on high-performance IGU’s at similar outdoor temps - - - suggesting that indoor RH levels really were reasonable


Flat-grain lumber porch ceiling
buckled from accumulated
condensation.
OSB siding did not.


Note location of buckles relative to exterior walls
and cantilevered floor.
Attic remained dry - - - we checked



Minor cracking of exterior stucco, which is consistent with dimensional movement of the OSB sheathing



Shows that humidifier input to maintain set-points was inversely related to outdoor temp (as expected), and that humidifier Input was usually less than 14 L /day - - - In short, it usually didn't take as much water to reach set-points as calculated (remember that 0.2 ACH vent rate was assumed by calcs)

What happened (in the sheathing) inside the walls?

Instrumented walls

- Brick veneer (spaced) (NW)
- OSB lap siding (NE)
  - Not furred and furred w.o. vent openings
- Plywood panel (not furred) (SE)
  - x two
- Lime-Portland-Cement plaster (SW)
  - x two (plus one with interior polyethylene)

Shows that the spaced siding was only spaced - - not ventilated. Soffit facing was on before furring strips went up.

Finding 1

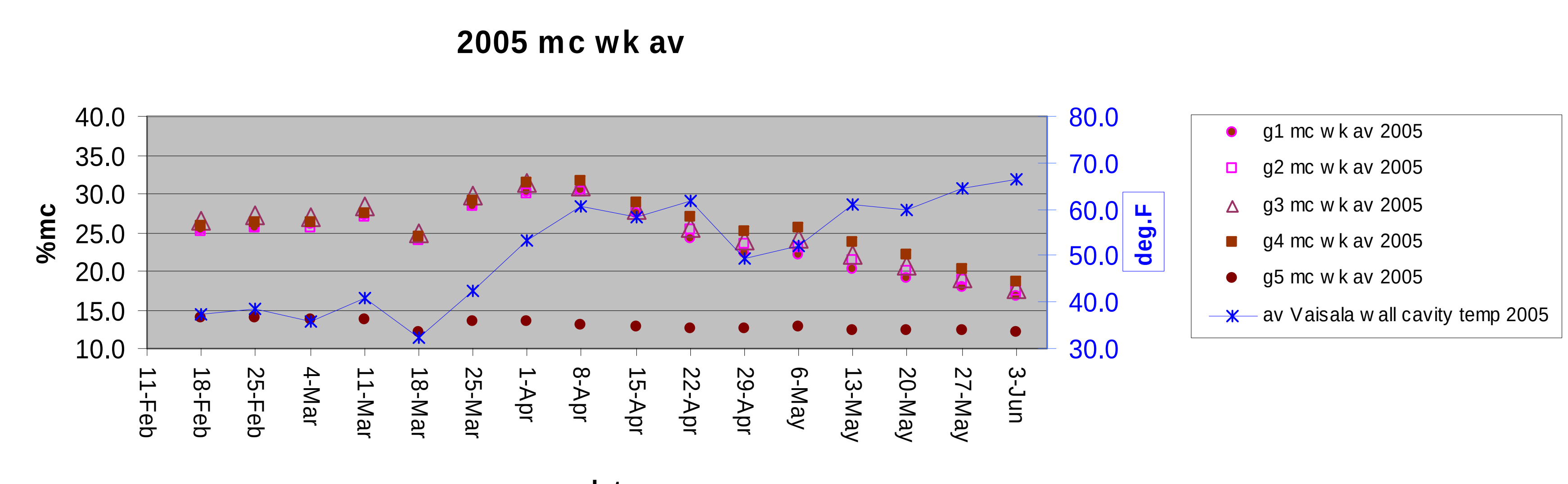
- Disturbingly high sheathing mc levels by February occurred in all walls (except the one with interior polyeth) in all heating seasons (even the first two - - w.o. any humidification)


Opened a (non-instrumented) wall toward end of 4th heating season

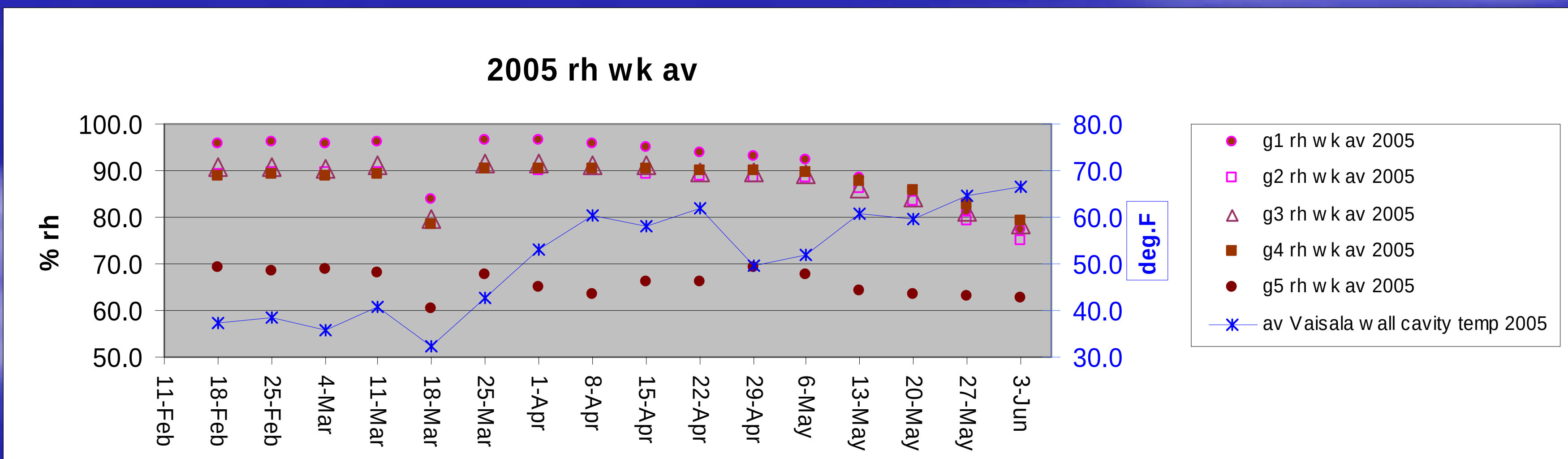
Saint Patty's Day 2005

Finding 2

Interior polyeth sheet kept the sheathing dry



g5 is the wall with the interior vapor retarder.



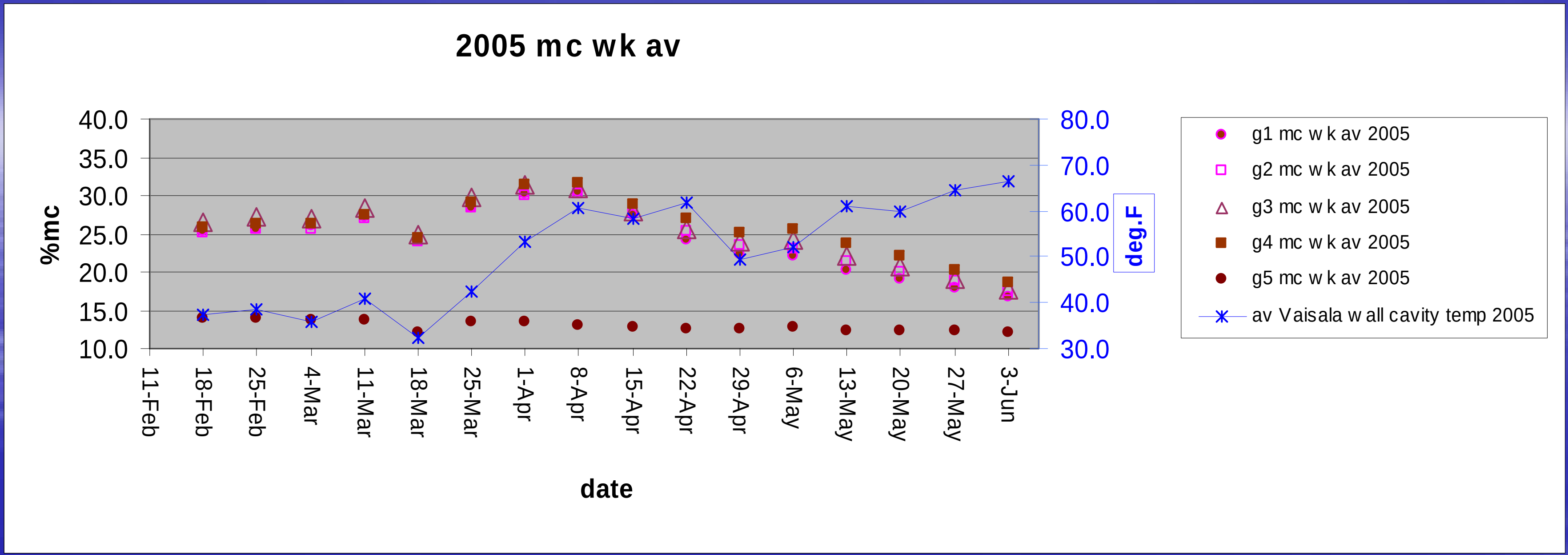
Sheathing mc and within-cavity RH, near the sheathing, show similar trends

Considerations re Finding 2

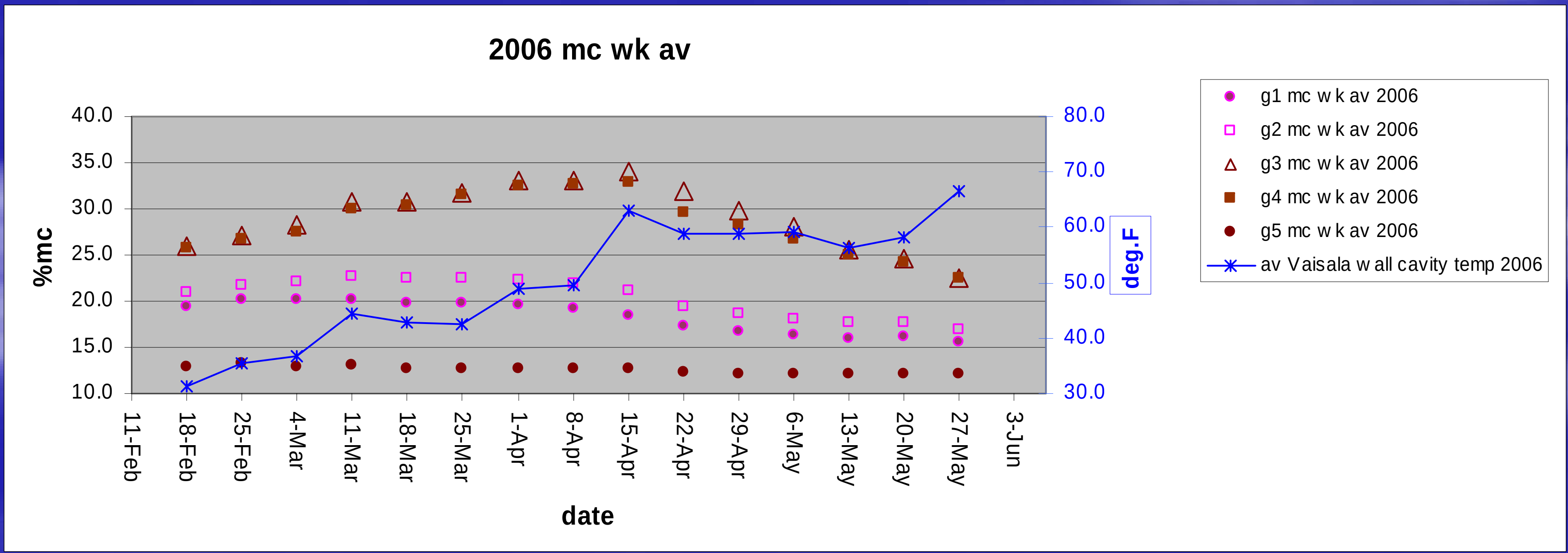
- Poly wall was SW-facing and stucco-clad (the other stucco-clad instrumented wall spaces were SW-facing too)
- But it was 1-story with modest roof overhang and functioning gutter
- The influence of poly (which was distinctly beneficial on this building wall) might not be so beneficial in another climate - - - or in a stucco-clad wall with significant windblown rain exposure

Finding 3

- Contemporary latex vapor retarding paint was not as effective as polyeth sheet, but it definitely helped.

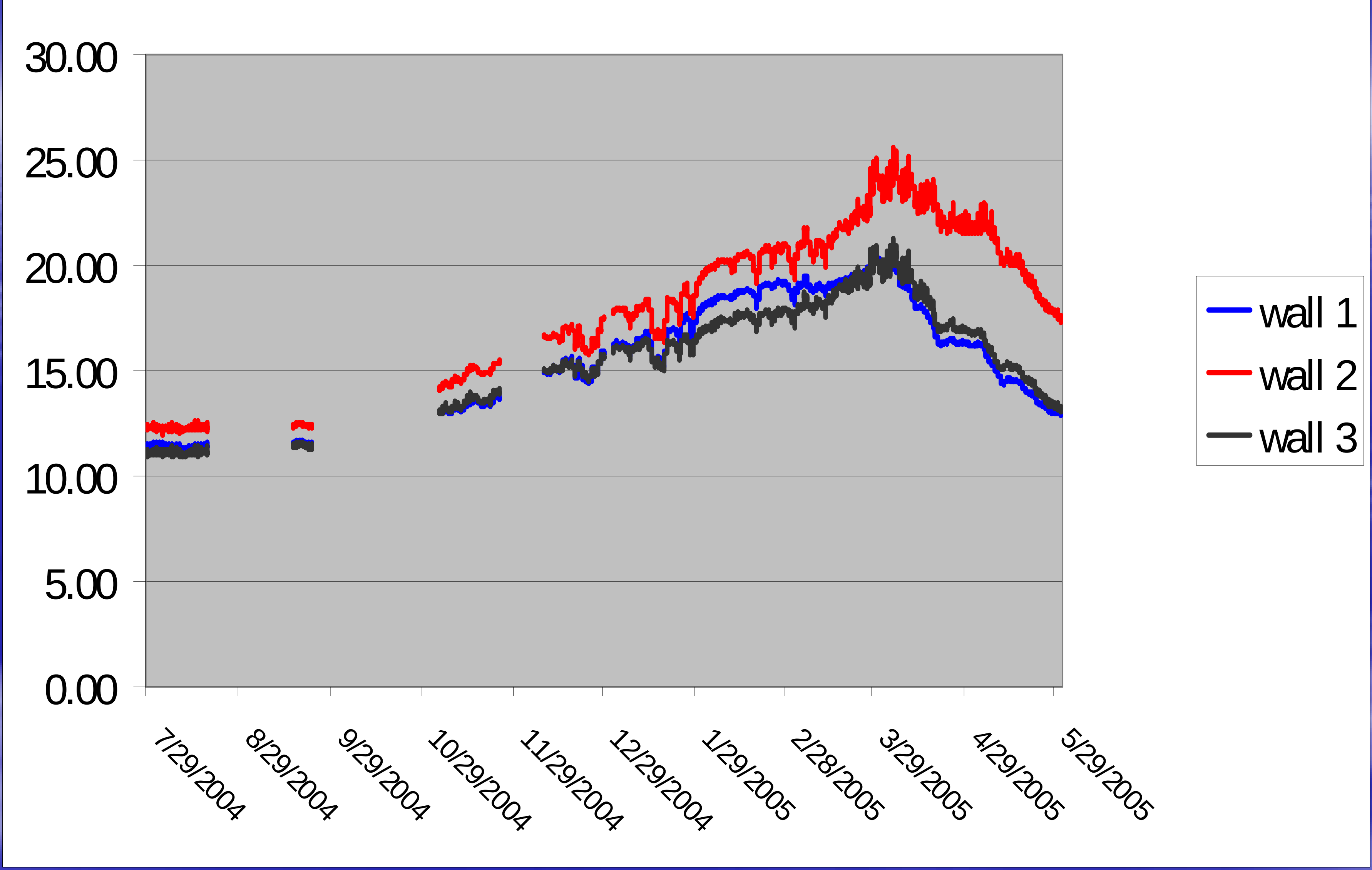


Walls g2 and g3 got a coat of vapor retarder paint in early Oct. 2005

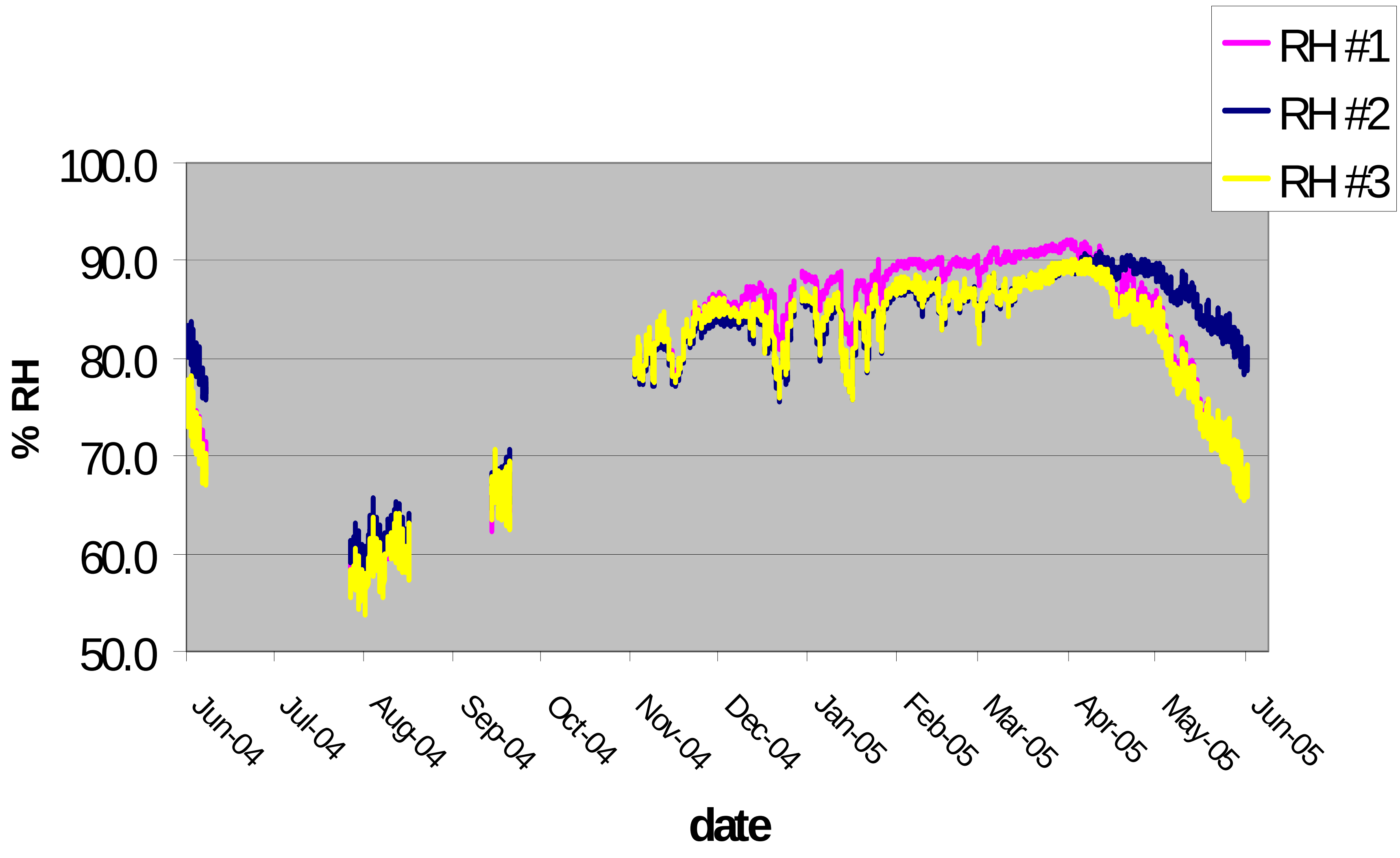


Findings 4a and 4b

- Spacing the cladding out from the sheathing resulted in more rapid springtime moisture dissipation.
- Sheathing on north-facing walls behind spaced brick or spaced OSB lap siding had more favorable moisture history than sheathing on south-facing walls behind un-spaced plywood panel siding or behind stucco.



Wall 2 had unspaced OSB siding.
Walls 1 and 3 had spaced brick and OSB claddings, respectively



Springtime reduction in within-cavity RH was slower when cladding wasn't spaced

Conclusion(s)

- At design interior conditions, in a 6800 HDD climate, lack of an interior vapor retarder results in wintertime moisture accumulation in OSB sheathing (at least in 2x6 walls), - - - - - sufficient for a 16% mc max in-service value (assumed by the APA Engineered Wood Handbook) to be exceeded.
- Spacing the cladding out from the WRB appears to be helpful

Parting idea re Conclusion 1

- “We worry about sheathing getting wet during the winter, but it rots during the summer”.
- This quote is factual, but 1980’s experience indicates that decay fungi can eventually do their (destructive) thing to sheathing on winter-accumulated moisture each spring (incrementally - - year by year) - - - unless springtime dissipation is rapid.

The traditional reason for installing a vapor retarder was exterior paint performance - - - that's not necessarily the case now

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