BUILDINGENERGY

Online Community of Northeast Sustainable Energy Association

# Building Science Puzzles

## How Heat & Moisture Moves Through Homes

# Premises

- Things get wet, heat dries them out.
- Energy efficiency measures reduce heat loss.
- Energy & moisture must be managed with equal intensity.
- Follow the water.

# How many ways can a building assembly get wet?

- Bulk water
- Wicking
- Air-transported moisture
- Diffusion

- leak, inside or out
- capillarity of porous materials
- air leak
- interior-exterior gradients, created by space conditioning & climate

# How many ways can a building assembly dry?

- Free drainage
- Convective
- Diffusion
- Space
- Pathway and driving force
- Evaporation

# Mold/Rot Basics

- Temperature/Food/Water
- Molds (spores) are everywhere, all the time…
- They like the same temperatures we do…
- They like many of the materials out of which we like to build…
- Mold generally shows up at 19% MC or higher
- Rot requires 25- 28% MC
- The easiest/most effective approach to control mold/rot is, generally, managing moisture.

# Sources - Household Moisture

Source: Minnesota Extension Service

| **Source** | **Quantity (pints)** |
|---|---|
| Showering | .5 (5 - min shower) |
| Clothes drying | 4 - 6/load |
| Cooking (dinner) | 1.2 (+1.5 gas) |
| 5 house plants | 1/day |
| 1 cord “green” wood | 600 - 800/season |
| 4 people | .5/hour |
| Building materials | 6 - 17/day |
| Ground moisture | 0 - 100/day |

# Puzzle List (approximate “number of pieces”)

| | |
|---|---|
| Interior mold mitigation | 500 piece |
| Attic mold in saltbox (5A) | 500 piece |
| Basement moisture in historic municipal building DER (5A) | 750 piece |
| Closet mold in tenant cottage (6) | 1000 piece |
| Water in cathedral ceiling SIP timber frame (5A) | 1000 piece |

# Ignore the client; do the “edges” first…

- Existing info
- “Walk” the exterior (bulk water)
- Foundation (bulk & capillary)
- Assess air leakage
- Interior RH and MC

# Puzzle 1 (Zone 6) – Insurance co. mitigated kitchen mold keeps coming back…

# View as you drive up…

# Pieces

- Mold insurance claim
- Mold mitigated once
- Building scientists called in
- Structure at bottom of steep hill with lake on opposite side
- Insurance inspector “baffled” by mold returning; did not know what sort of foundation the older part of home had

# Crawlspace inspection…

# Key Takeaways/Lessons Learned

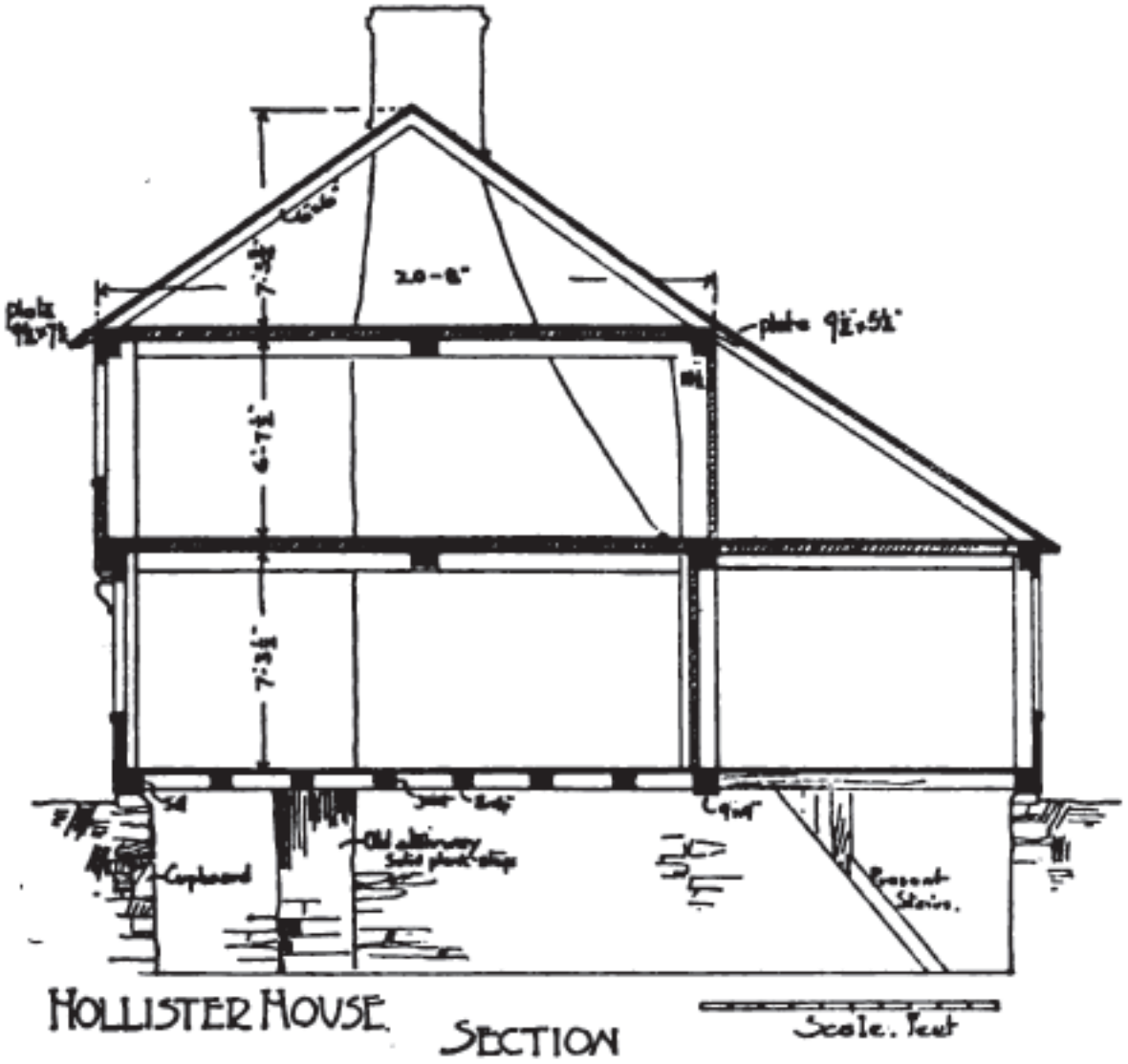
- Ignore the client; do the “edges” first…
- Existing info
- “Walk” the exterior (bulk water)
- Foundation (bulk & capillary)
- Follow the water…

# Puzzle 2 (Zone 5b) – mold in attic

# Mold in the Attic

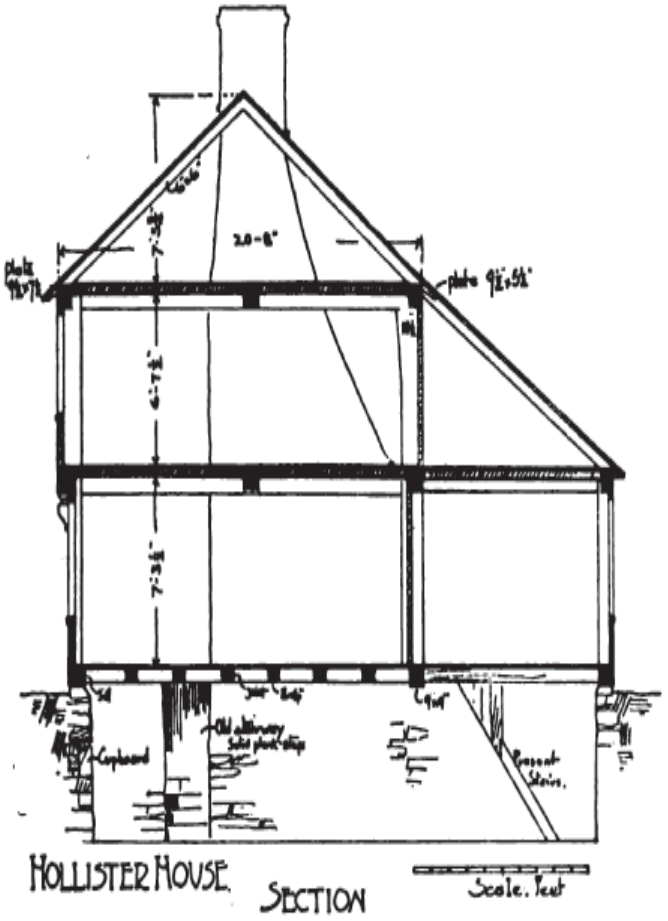
# North side

# Classic “Saltbox”



# Pieces

- Mold in attic
- Home inspector: inadequate attic venting
- HI “solution:” add mechanical attic exhaust

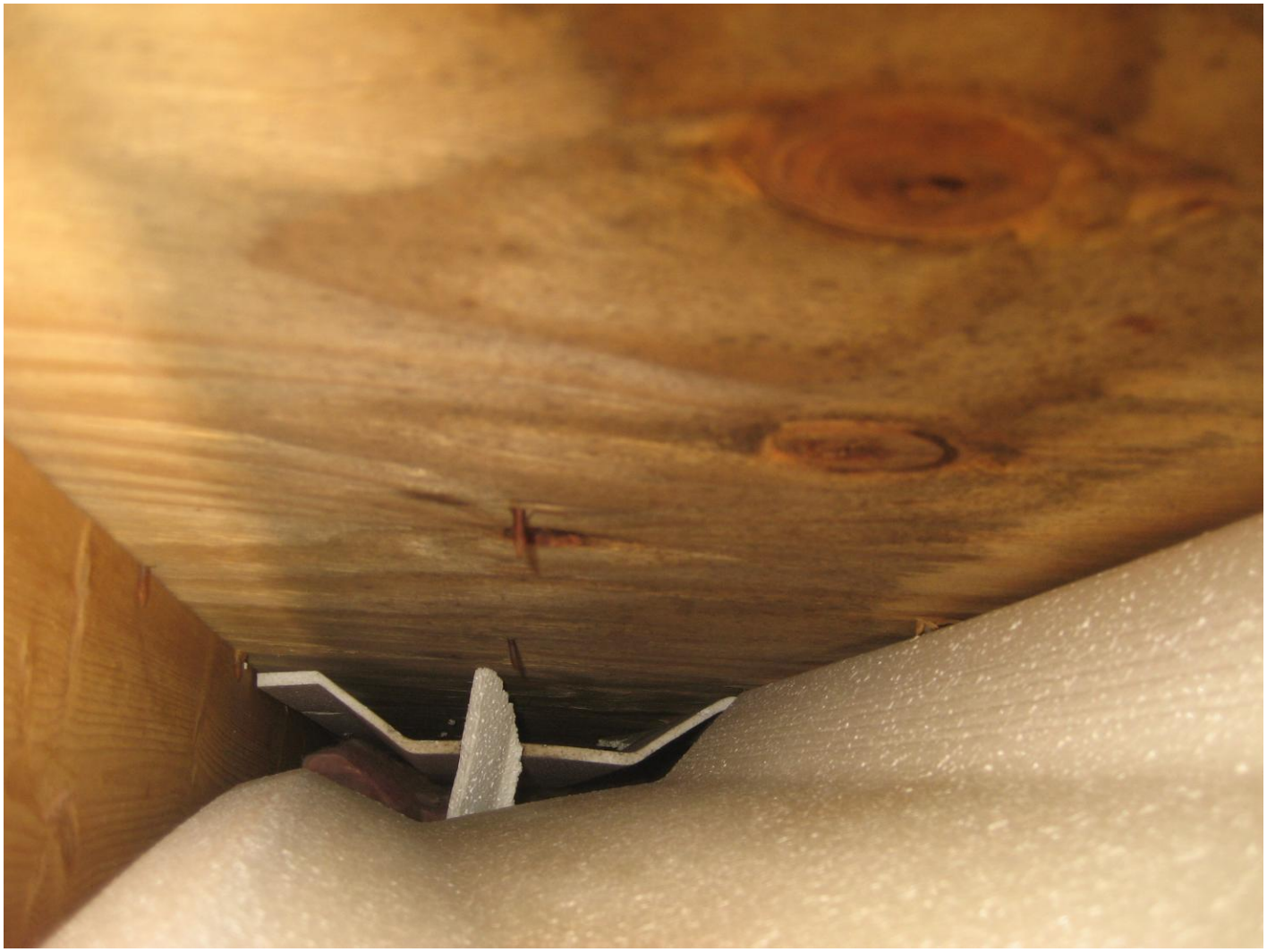


# Original diagnosis: inadequate attic ventilation

# Only on the North side

# Mold in the Attic

# In the knee wall



# Patterns in the Attic Mold?

# Only on the North side

# Key Takeaways/Lessons Learned

- Patterns of moisture expression are key
- Back-up “arm-chair” building science with on-site full confirmation
- Follow the water…

# Puzzle 3 (Zone 5b) – DER with damp basement

# DER of 1st & 2nd floor office space but concerns with damp basement

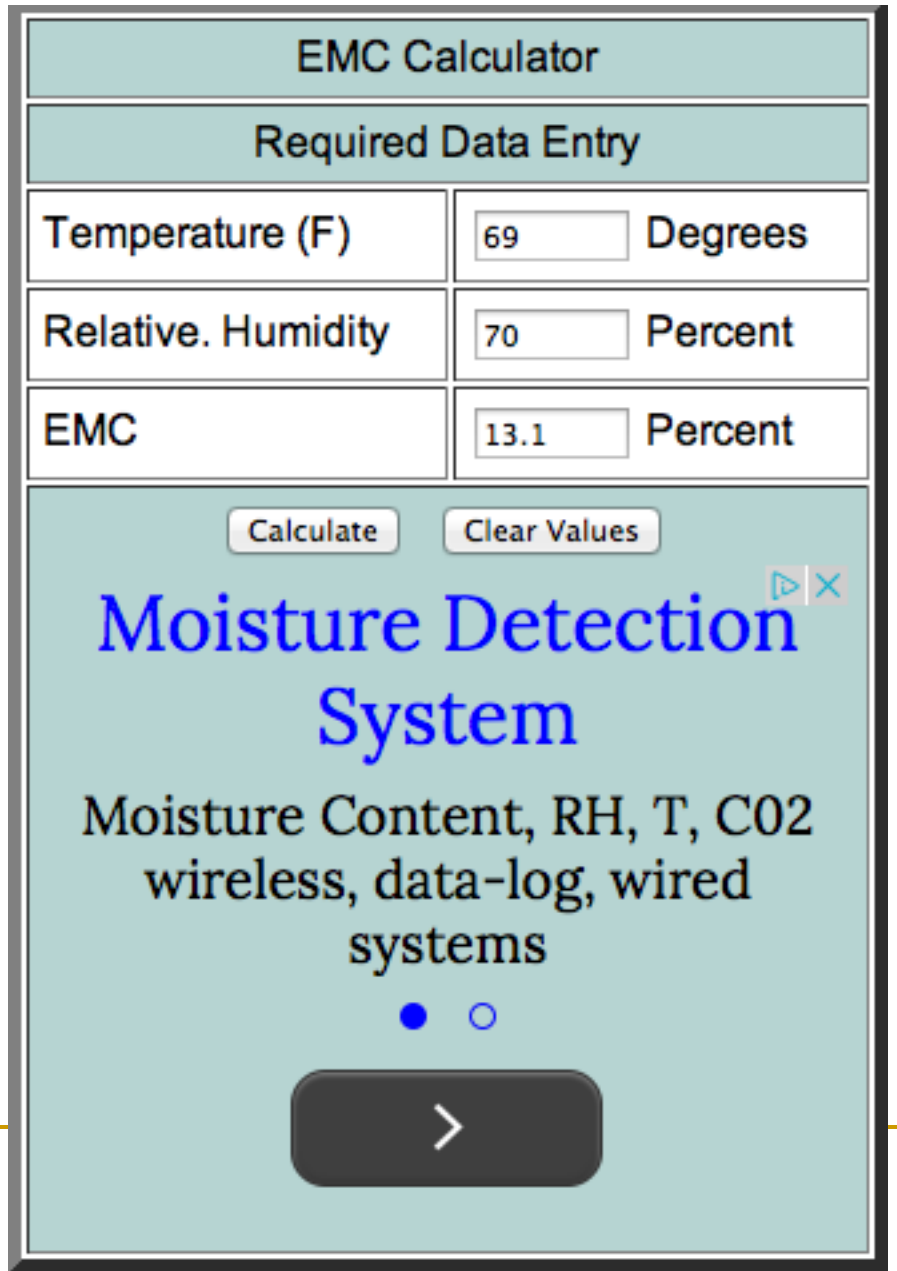
# Pieces

- Interior gut of wood-frame building to significantly improve energy efficiency
- Engineer on project encouraged hygrothermal building assessment
- Significant moisture issue(s) in basement

# Moisture data from basement

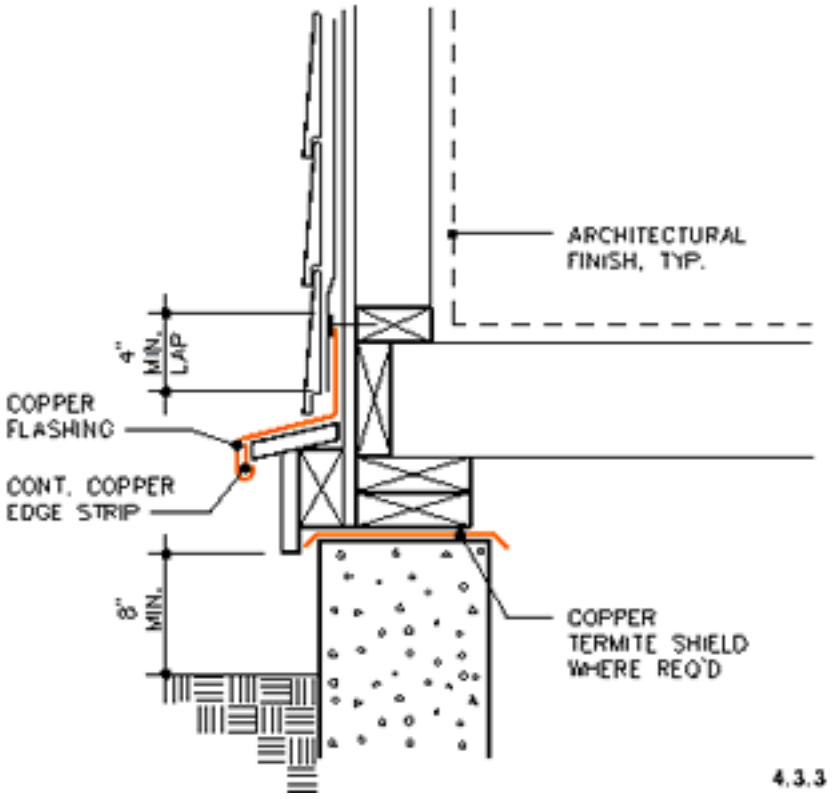
- Thermastor Santa Fe DEH set on 70%
- Hygrometer readings: 69F, 70% RH
- 1st floor framing in direct contact with brick foundation; MC readings, generally: 12 – 13%
- 2 spots with 19% MC

# Equilibrium moisture content (EMC)



# Bulk water manage 2 “spots”

# Re-building the wood siding water table with rigid insulation




Detail from Copper Development Association Inc.

# Key Takeaways/Lessons Learned

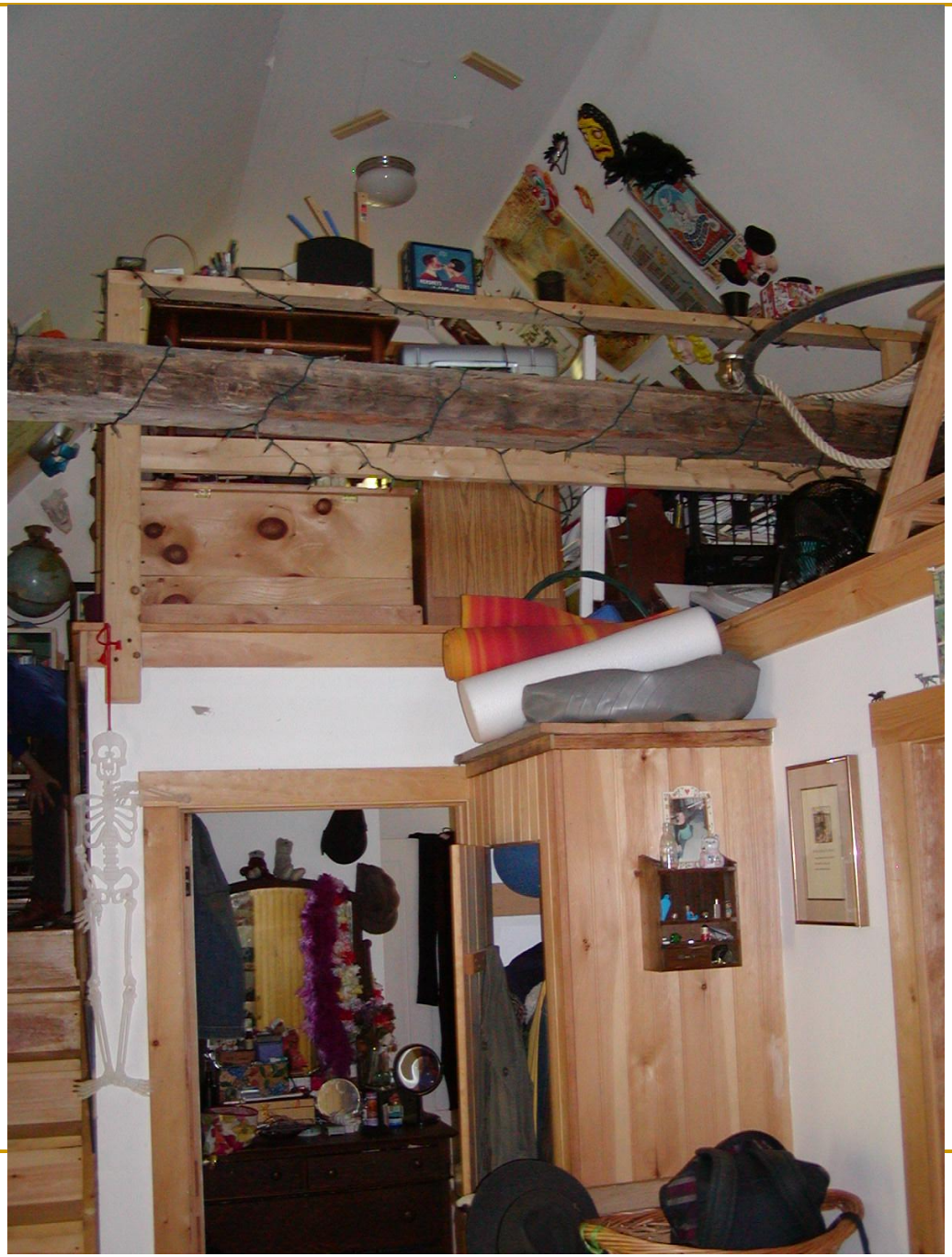
- Correlate wood moisture content with RH, if you can
- Maintain or improve moisture-energy balance
- Warm suspect elements when you can

# Puzzle 4: rental cottage (Zone 6) – mold in closet

# Pieces

- Crawlspace foundation: vented, unconditioned
- 4 years old
- One story open floor plan with loft
- 600 sq. ft. – two adult occupants
- Cathedral ceiling
- Standard wood-framed construction
- Airtightness not known
- Moisture/mold issues in closet/ceiling


CIRCUS
Back Pain



# Key Takeaways/Lessons Learned

- Assess the whole building (ignore the client…until they “get it”)
- Occupant density matters
- Assess and manage all sources of moisture
- Ongoing monitoring may be required

# Puzzle 5 (Zone 5b) – SIP timber frame roof/attic moisture

# Cathedral ceiling moisture issues, inside…

# …and out..

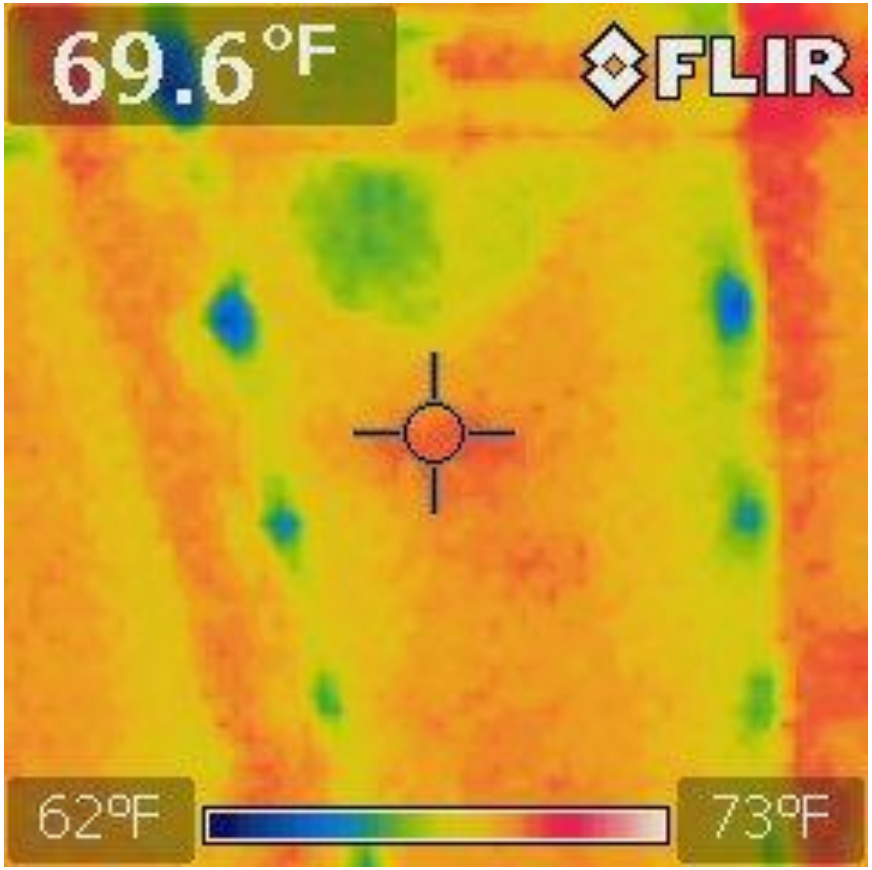
# Pieces

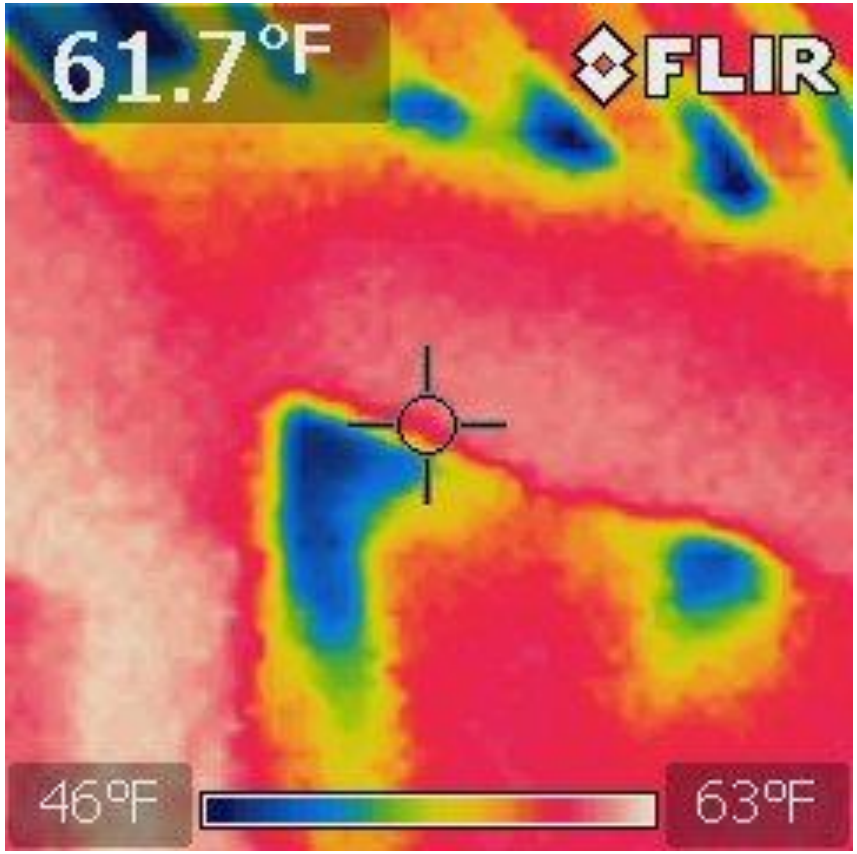
- SIP timberframe 1988
- Story and a half cathedral 28 by 32
- Knee wall attic space (over front porch)
- Roof assembly
  - Asphalt shingles
  - 30# felt
  - Nailbase EPS SIP
  - 6-mil poly
  - Structural/finish 2 by 6 T&G v-groove boards
  - 4-foot on center roof timbers

# Pieces (cont'd)

- Twenty years of moisture/ice on windows
- 5-year old re-roof of south side (driven by wintertime moisture damage at skylights)
- 5-year old HRV system (moisture control)
- Tight house: 500 cfm50
- North side, last year: moisture in attic space, lots of it in November – tried to manage with gable end venting
- Invasive inspection of north side: dry assembly, sound, plywood "moist"

# More info…BPI audit



# Why north side eave moisture now?

- Nailbase SIP butted/foamed
- Cyclical contraction-expansion finally broke the seal
- Air leakage in this unvented, double-vapor barrier assembly results in wintertime condensation running to eaves (?)
- Solutions?
  - Rebuild roof with venting and continuous air barrier
  - Manage wintertime air leakage with pressure?

# Countering stack effect

[SEE STACK DEMO HERE]

# Countering stack effect

- Negative pressure created by re-balancing the HRV?
- Installing a hi-efficiency exhaust fan?
- Increase effectiveness of negative pressure approach by air sealing what you can, particularly the problem areas easy to get to: gable end cathedrals…

# Job site data on pressures

**Manometer Readings**

**Dwelling**

| | Temperature (F) | | | Exhaust Fan Setting (#s in Pascals) | | | | Relative |
|---|---|---|---|---|---|---|---|---|
| Date | Interior | Exterior | Difference | High | Medium | Low | Off | Humidity |
| 11/23/14 | 66 | 56 | 10 | (6.6) | (5.6) | (3.8) | 0.7 | 18% |
| 11/6/14 | 64 | 49 | 15 | (6.5) | (5.5) | (3.4) | 1.2 | 43% |
| 11/9/14 | 62 | 42 | 20 | (6.1) | (5.1) | (3.0) | 1.4 | 36% |
| 10/31/14 | 63 | 38 | 25 | (5.7) | (4.6) | (2.5) | 1.6 | 46% |
| 11/3/14 | 61 | 31 | 30 | (5.2) | (4.0) | (2.1) | 1.8 | 34% |
| .11/15/2014 | 61 | 26 | 35 | (4.6) | (3.5) | (1.9) | 2.0 | 27% |
| 11/18/14 | 60 | 20 | 40 | (4.0) | (3.0) | (1.5) | 2.4 | 18% |
| . | | | | | | | | |

# Any unintended consequences?

- What about radon in all this?
- House closed 3-day test, HRV off = 8.4 pC/l
- House closed 3-day test, HRV on = 2.4
- Cold weather test with negative pressure = 2.8

# Key Takeaways/Lessons Learned

- Chronology is always important
- Takes an unusual client to conduct “distance-directed” investigations
- Everything is connected to everything else…

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Home » Conferences » BuildingEnergy 15

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