

Moisture Reduction Impacts of Radon Resistant Construction: When Does it Help?

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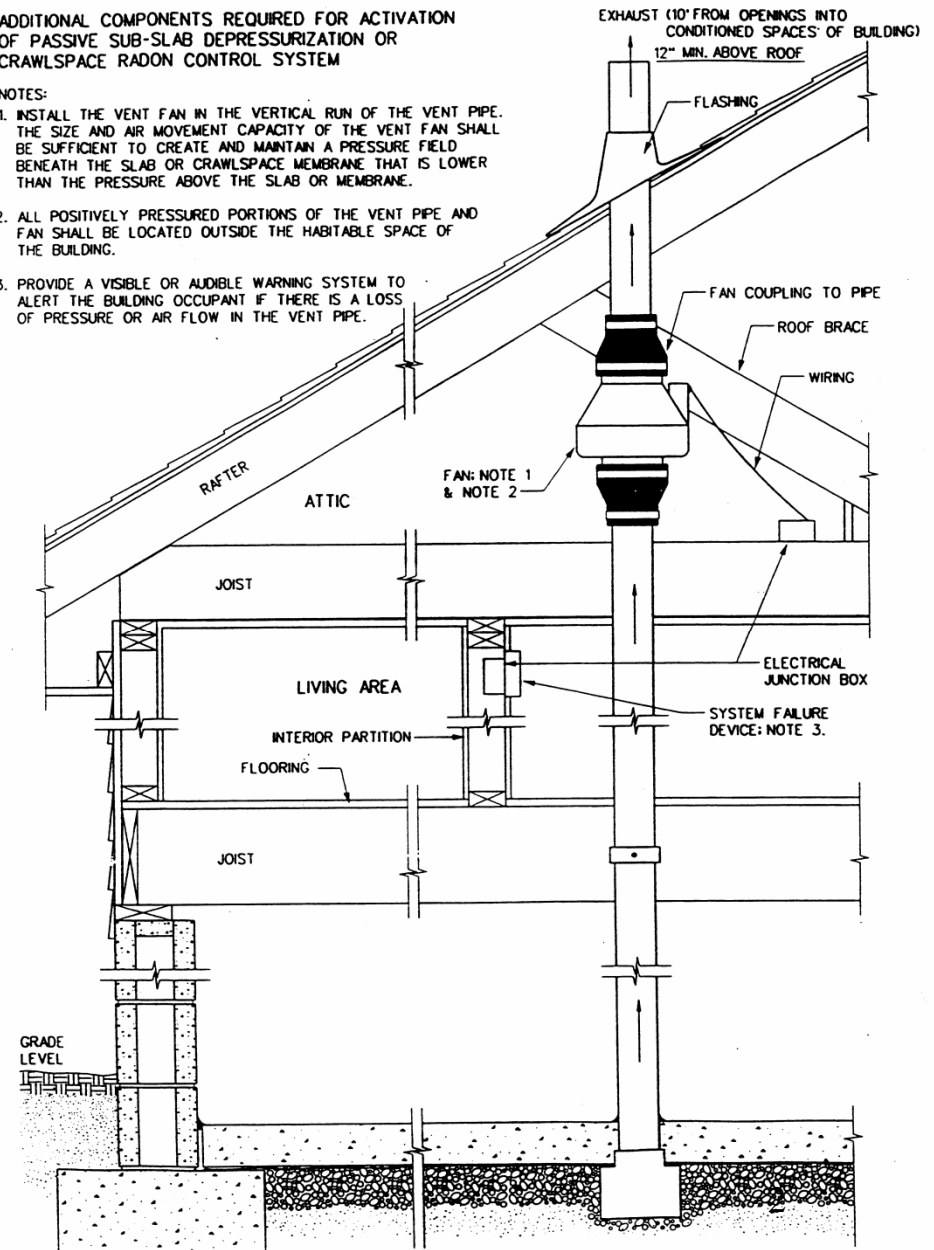
ASD = Active Soil Depressurization

Most cost-effective method of controlling soil gas entry: radon, land-fill gases, chemical vapors

ADDITIONAL COMPONENTS REQUIRED FOR ACTIVATION OF PASSIVE SUB-SLAB DEPRESSURIZATION OR CRAWLSPACE RADON CONTROL SYSTEM

NOTES:

1. INSTALL THE VENT FAN IN THE VERTICAL RUN OF THE VENT PIPE. THE SIZE AND AIR MOVEMENT CAPACITY OF THE VENT FAN SHALL BE SUFFICIENT TO CREATE AND MAINTAIN A PRESSURE FIELD BENEATH THE SLAB OR CRAWLSPACE MEMBRANE THAT IS LOWER THAN THE PRESSURE ABOVE THE SLAB OR MEMBRANE.
2. ALL POSITIVELY PRESSURED PORTIONS OF THE VENT PIPE AND FAN SHALL BE LOCATED OUTSIDE THE HABITABLE SPACE OF THE BUILDING.
3. PROVIDE A VISIBLE OR AUDIBLE WARNING SYSTEM TO ALERT THE BUILDING OCCUPANT IF THERE IS A LOSS OF PRESSURE OR AIR FLOW IN THE VENT PIPE.



Background

- Anecdotal reports of reduced ‘musty odors’ and dampness during ASD
- Asthma & respiratory ailments related to damp indoor environments
- Contractors now installing ASD, claiming moisture benefits
- Possibility of multi-pollutant control with a single technique (radon & moisture)
- Initial steps:
 - EPA literature search
 - Meeting of experts to draft project design

Overview of Exploratory Study

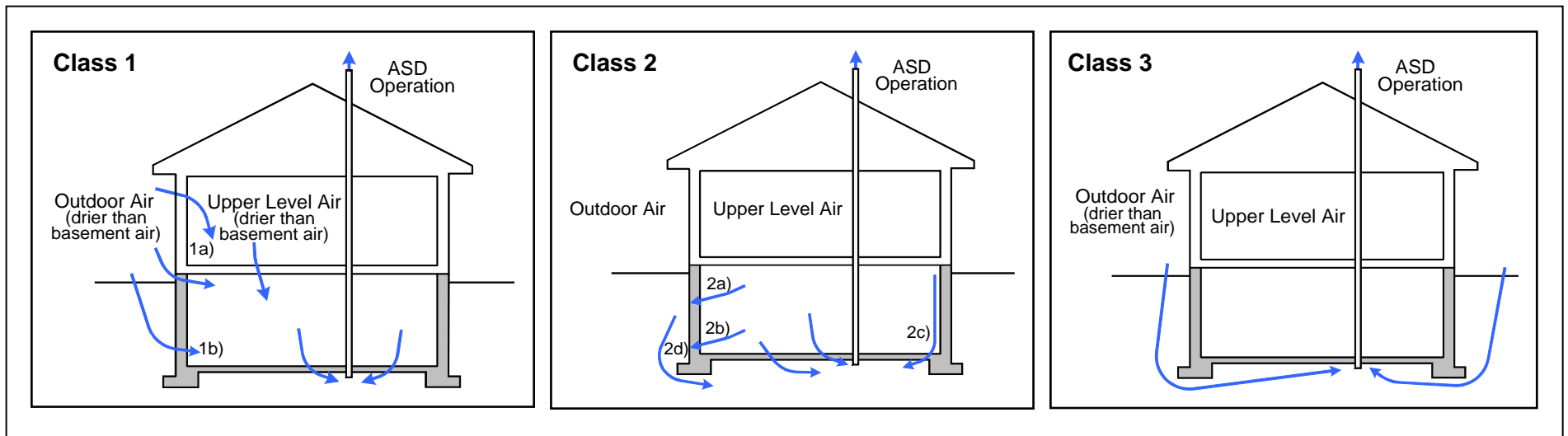
- Develop simple conceptual model
- Conduct field study in 3 PA houses
 - Full basements
 - Mostly unfinished & unoccupied
 - Slightly elevated radon
 - Moisture problems - but no liquid water
 - 2 with block walls, 1 with poured walls
- Install re-configurable ASD systems - cycled on/off (1-day to 14-day)
- Multi-parameter monitoring for 12 - 18 months

Conceptual Model

- Question: How would ASD affect moisture in basements?
- Premise: ASD could alter air flow patterns into, within, and out of building

Conceptual Model

3 classes of air flow



- *Moisture in buildings has many sources*
- *Air flows occur concurrently & can vary over time*
- *Upstairs & outdoors air can add/remove large amounts of moisture in basement*

Study Houses



Configurable ASD System





Field Tests & Measurements

Air Flow In & Out of Basement

Outdoors, Upstairs, and Soil

- *PFT Tracer Gas Ventilation Tests*
- *Differential Pressures*
- *Soil Gas/Radon/Moisture Entry Potentials*
- *ASD Velocity Pressures/Flow*
- *Wind Direction and Speed*
- *Air Leakage Area*
- *Effective Resistances (floor, soil)*
- *Radon Concentrations*
- *ASD Static Pressures*
- *HVAC On-time*

Temperature & Water Vapor Content of Air

Outdoor, Basement, Microclimate, Upstairs, Soil, ASD

- *Temperature & Heated RH*

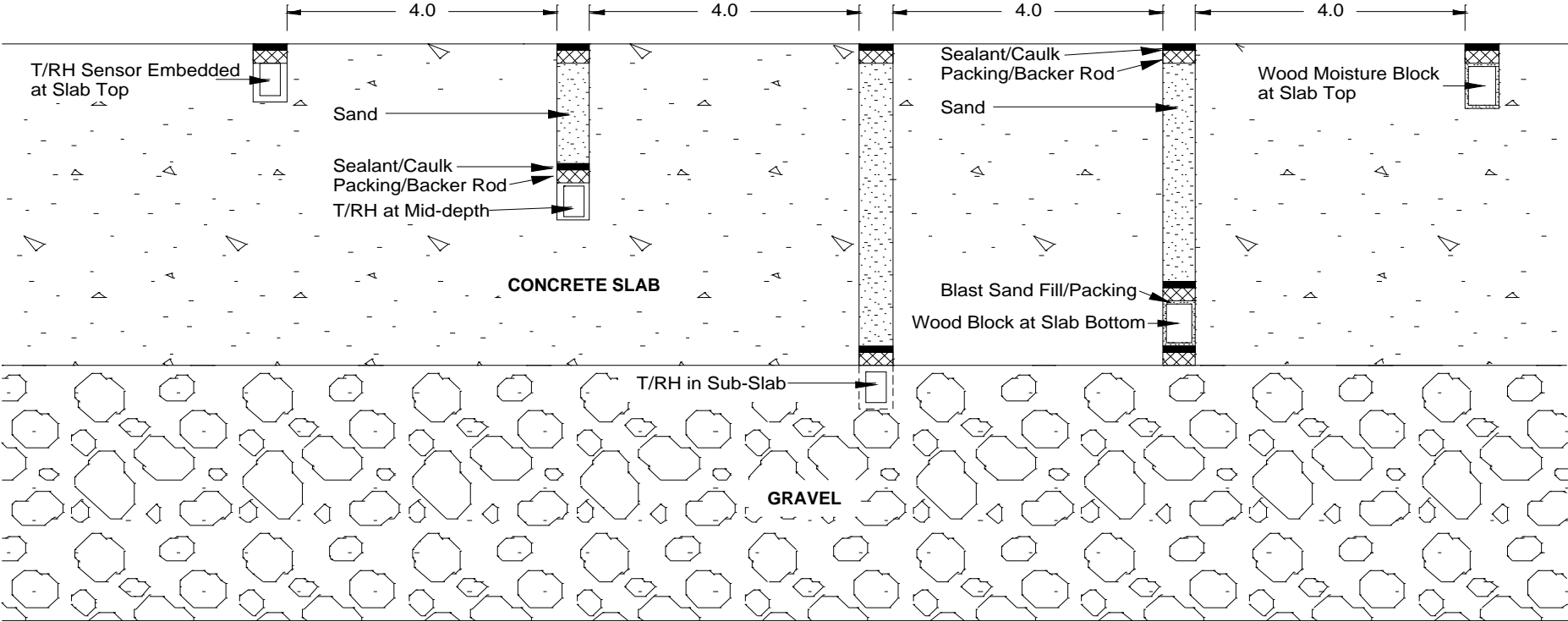
Moisture Storage & Diffusion

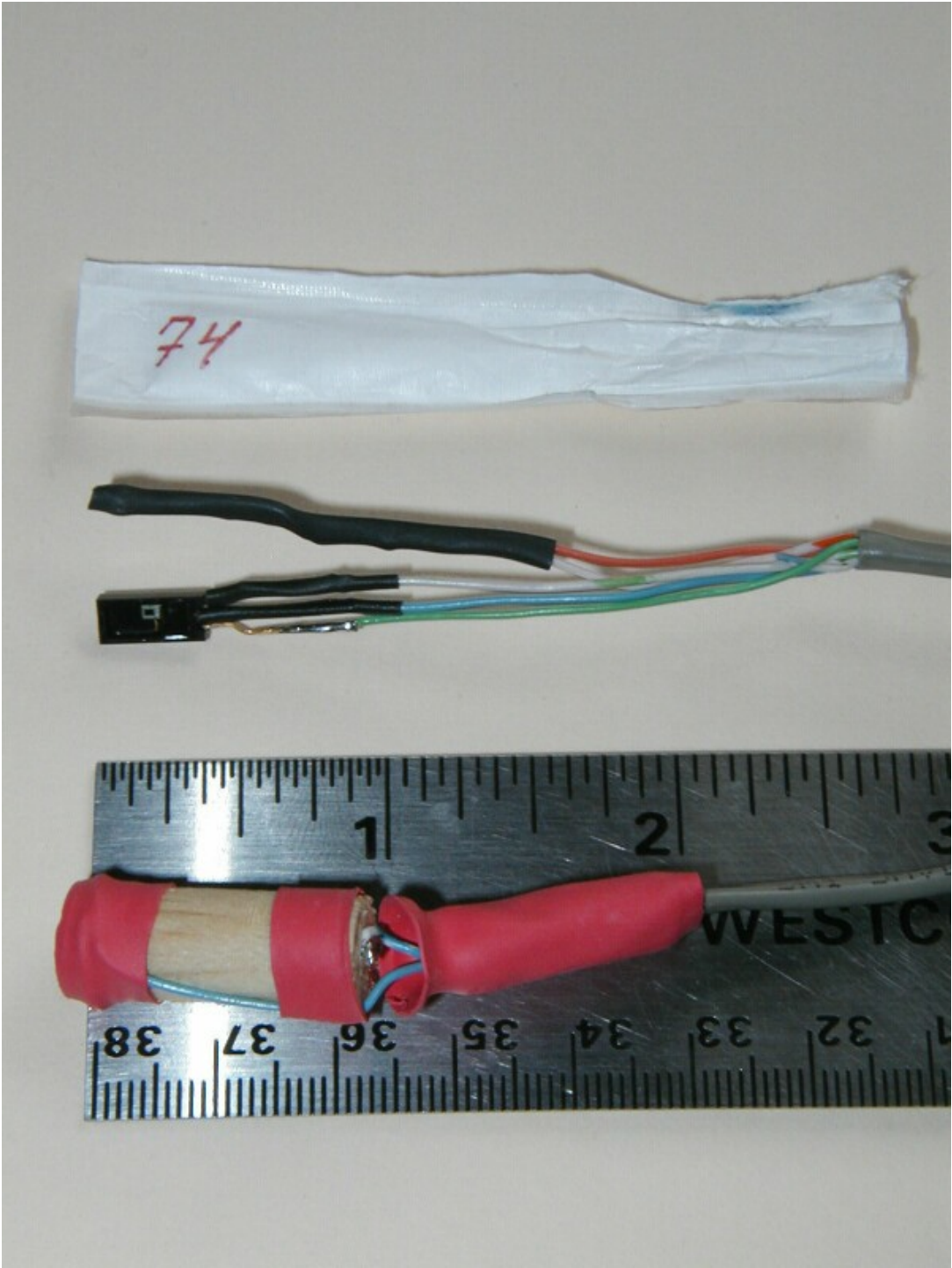
Walls, Floors, Wood Framing

- *Moisture Content Pins*
- *Wood Block Moisture Sensor*
- *Heated RH*

*Approx. 115 Parameters Recorded
Every Hour at Each of 3 Houses*

Slab & Wall Moisture Sensor Placement



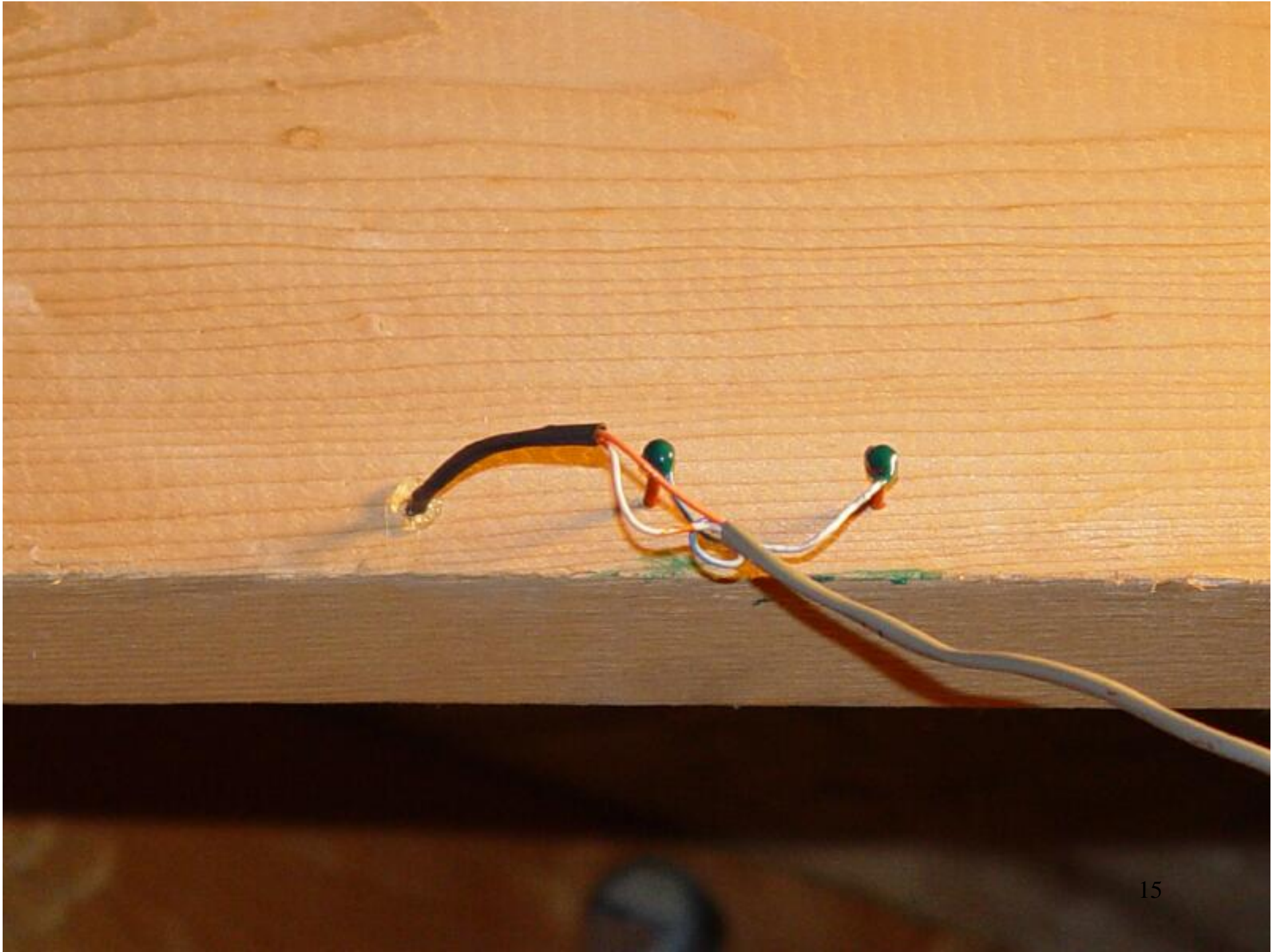


Sensors in Block Wall



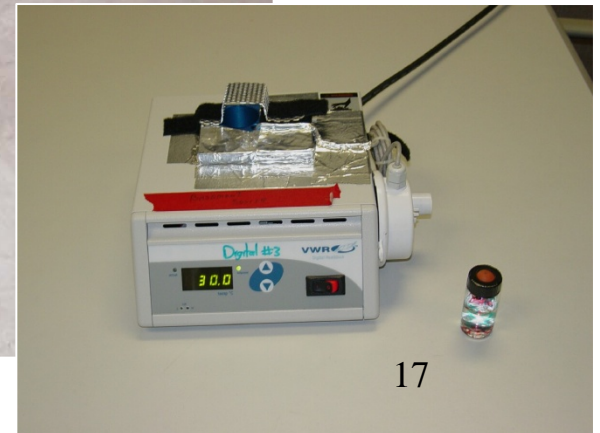
Temp/RH Sensor at Interior Slab Surface







Multi-tracer Interzonal Flow & Ventilation System

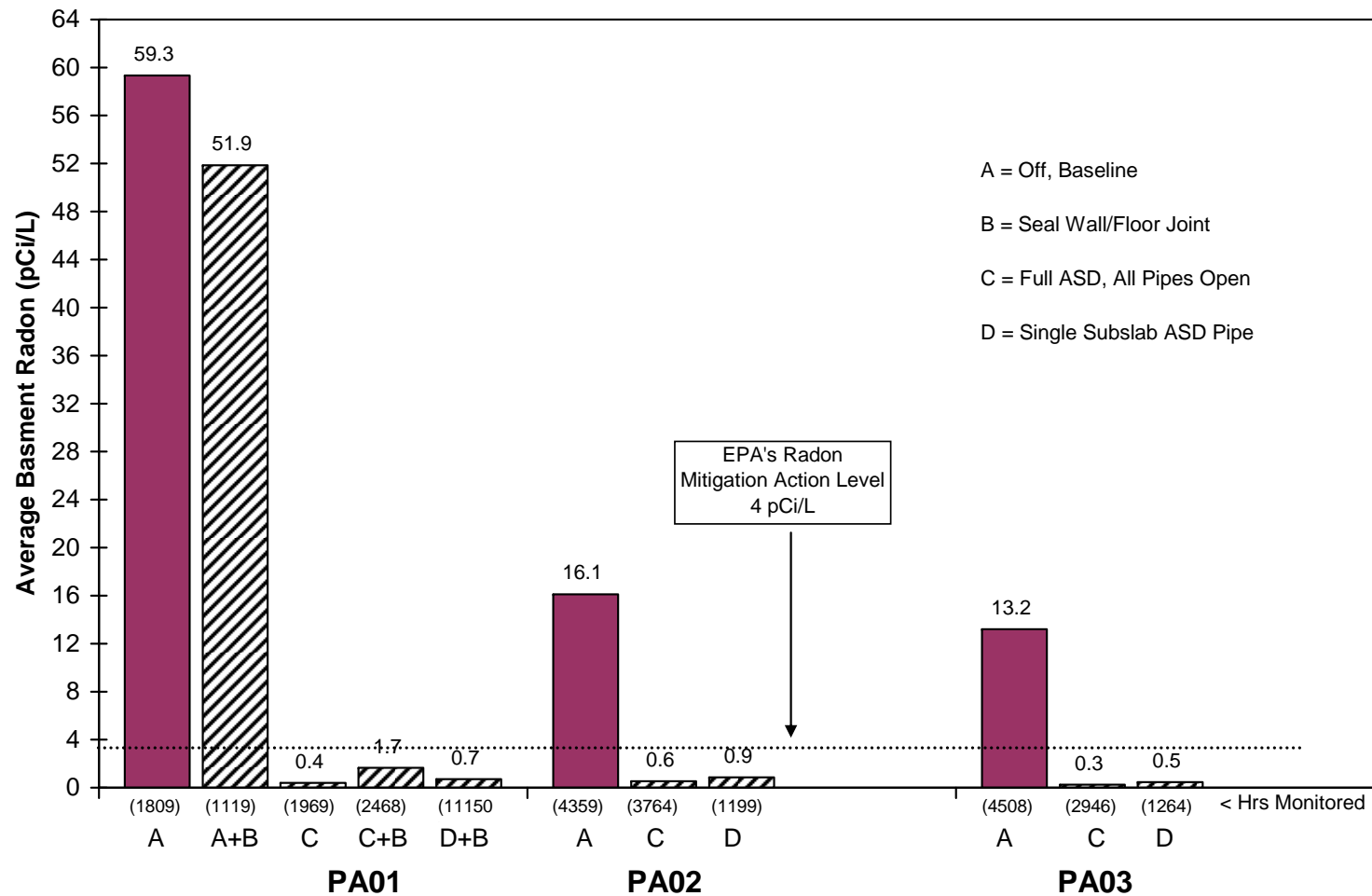


Dehumidifier & Condensate Monitoring

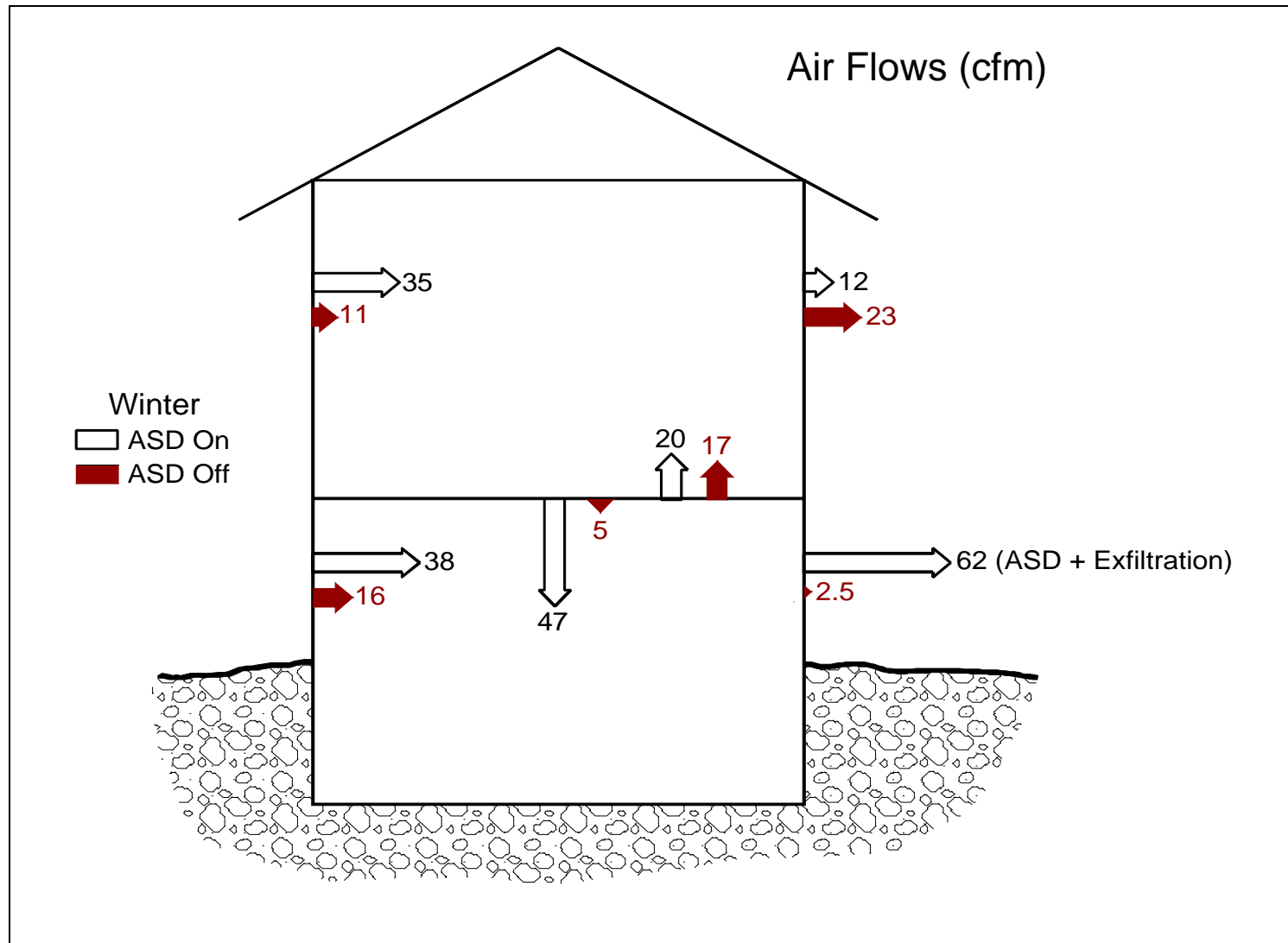


Indoor Radon

- Radon is dramatically reduced
- Usually, the dominant source of radon is the soil



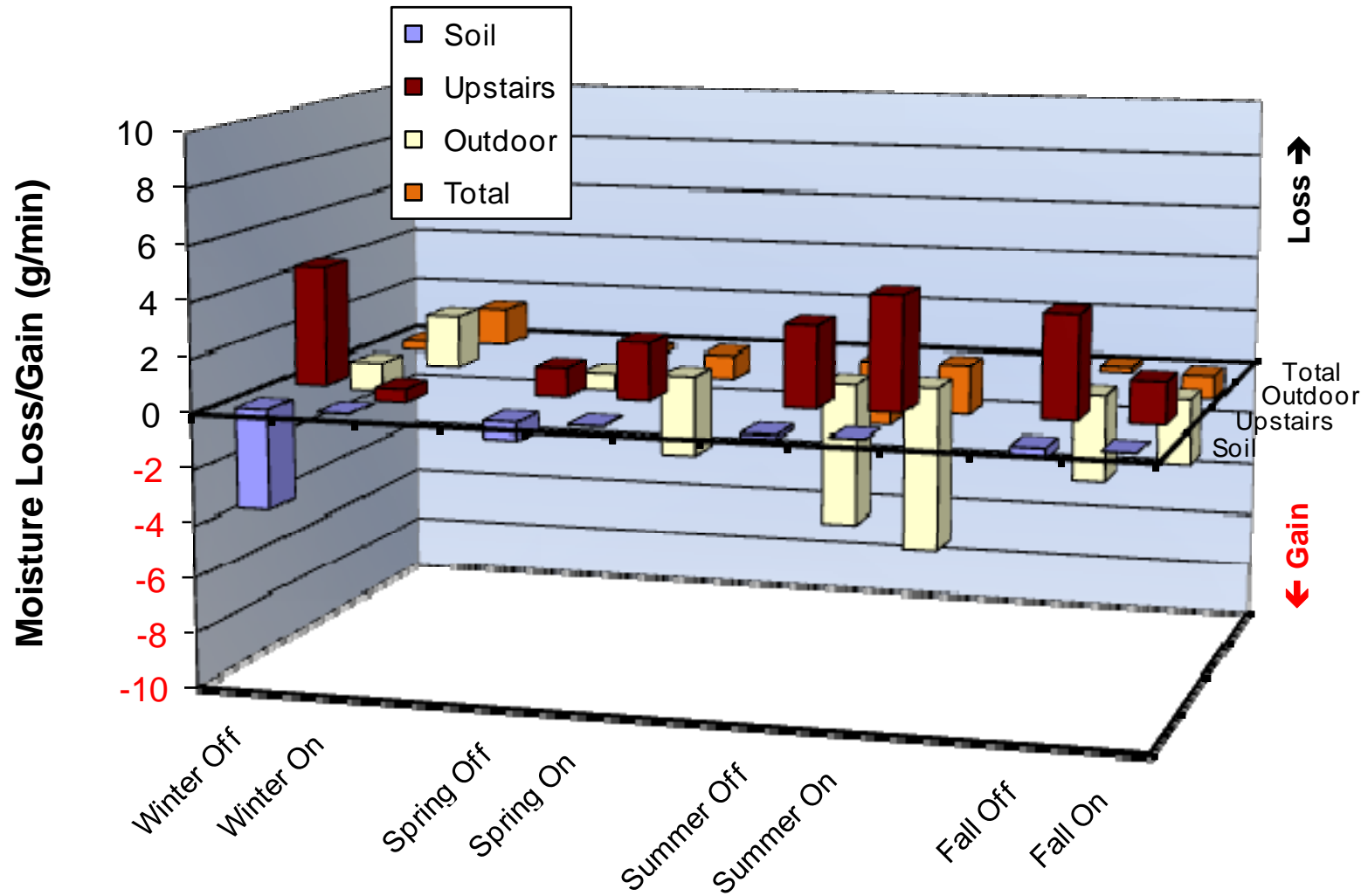
Measured Changes in Air Flow Patterns Caused by ASD (PA02)



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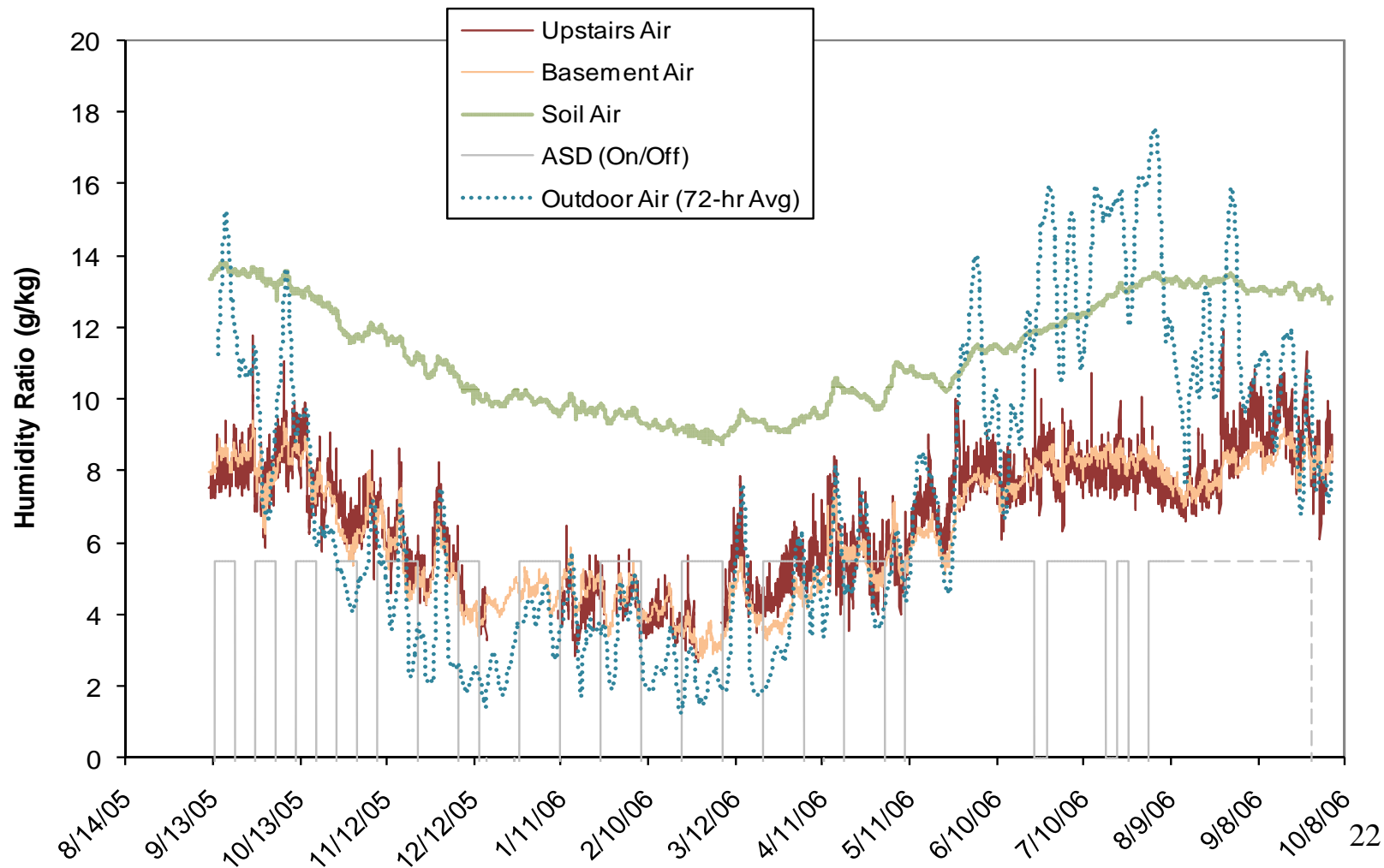
Multi-tracer sources and sample analysis provided by David Faulkner & Bill Fisk, LBNL

Net Convective Moisture Flow – PA01

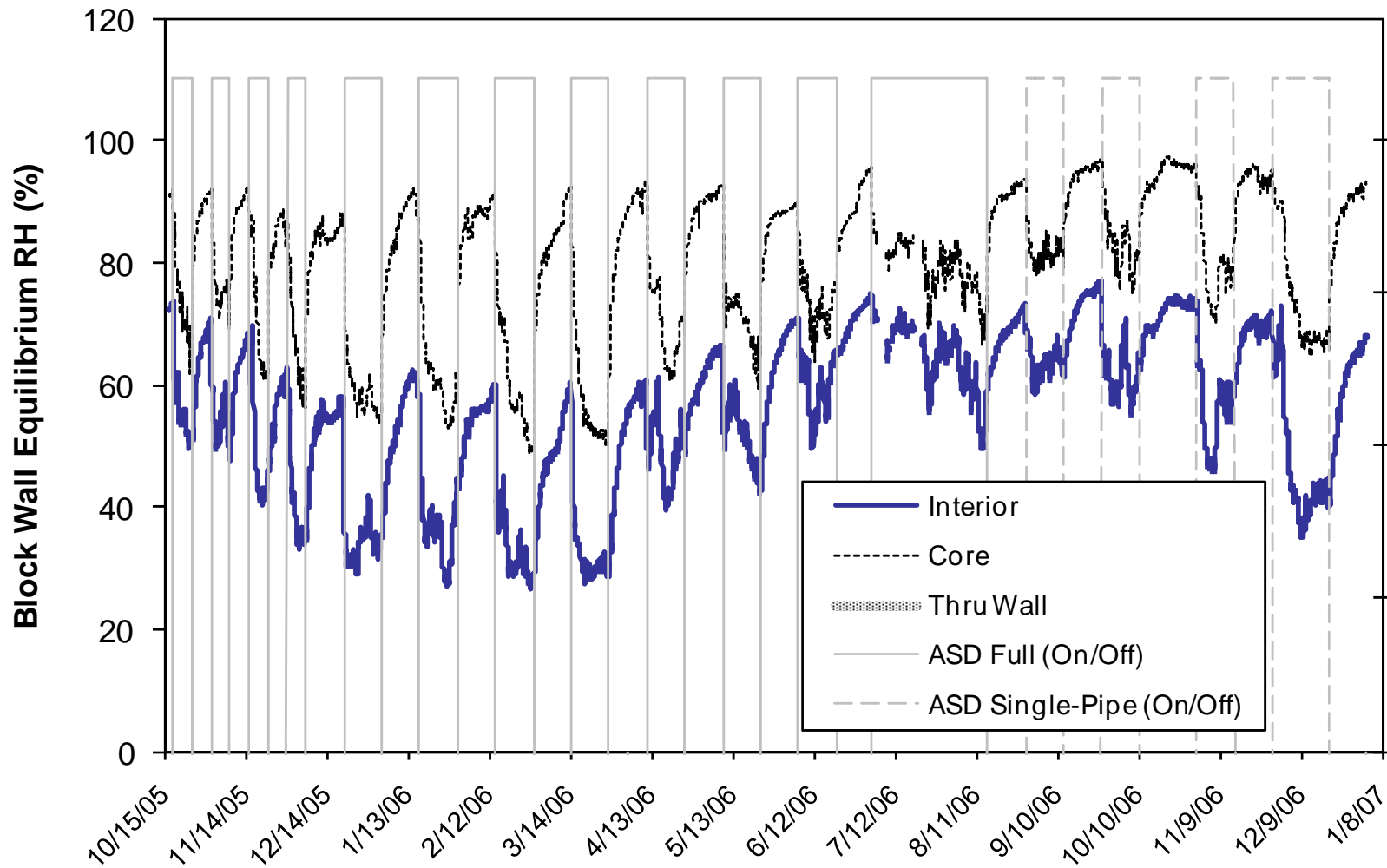


In these 3 houses, moisture in basement air tracks outdoor air moisture (PA01)

**Approx 70% of Variation in Basement Air Moisture Due to Outdoor Air

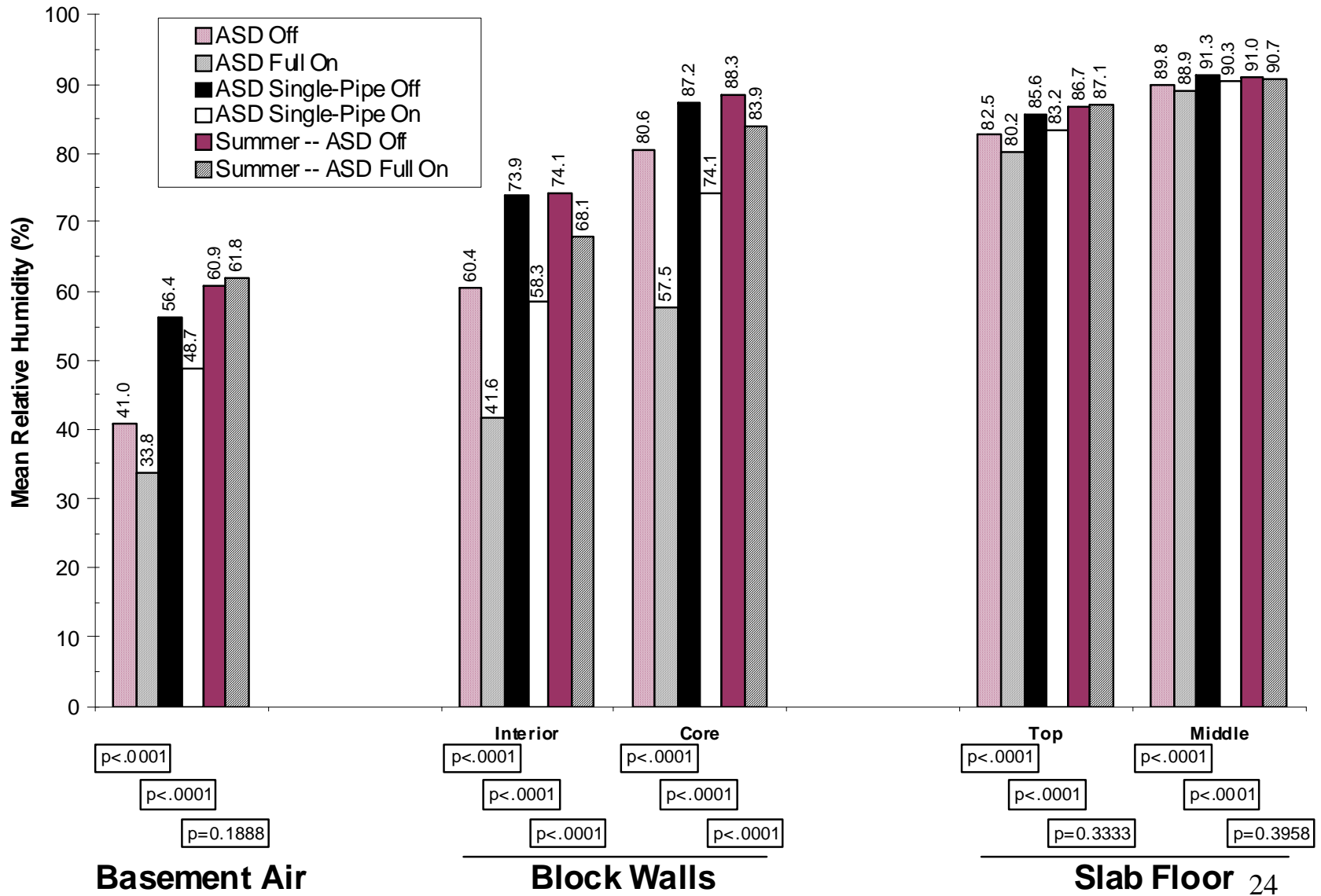


Wall Moisture - PA02



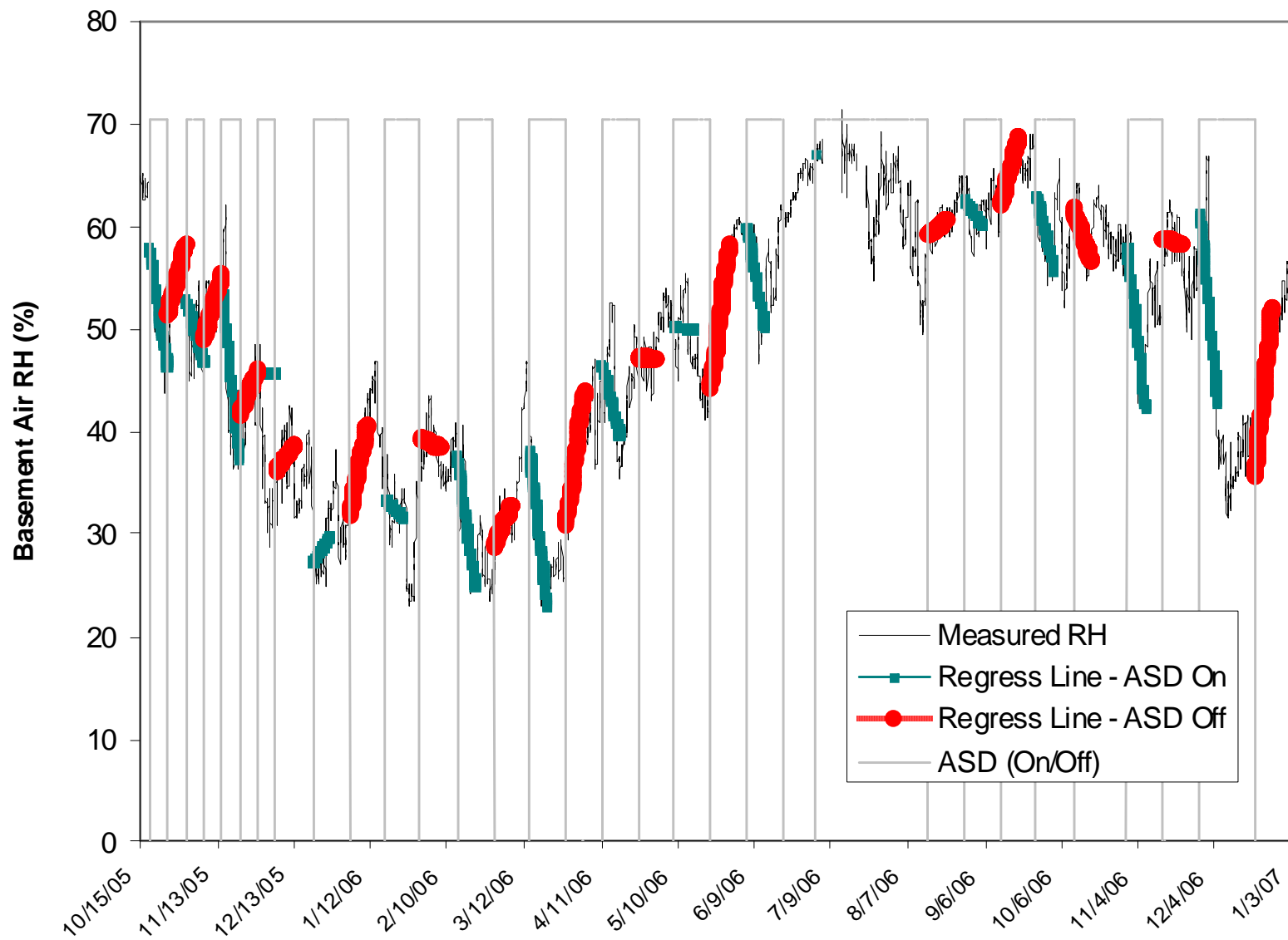
Mean RH -- PA02

Dec 2005 -- Jan 2007



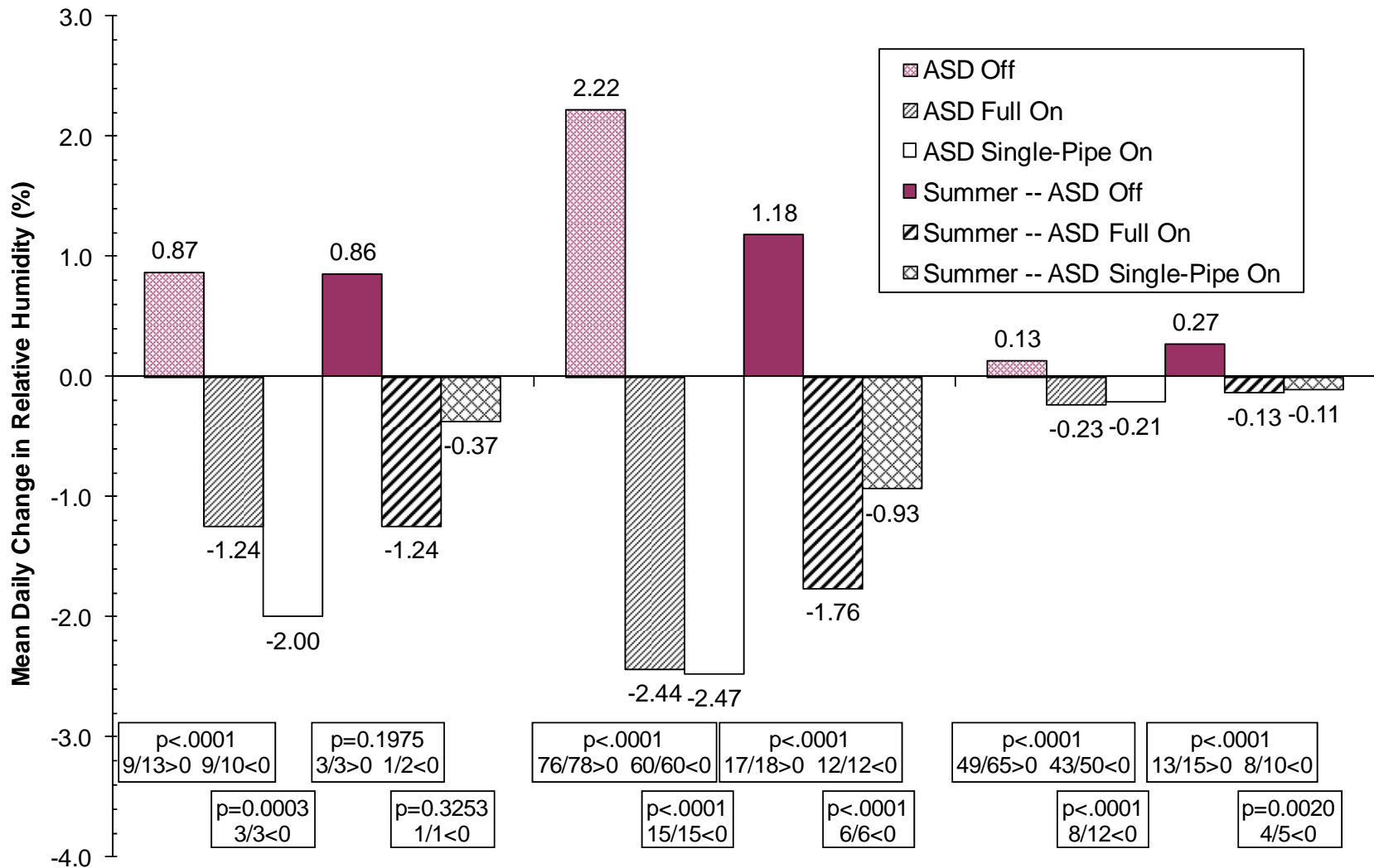
Second 7 days of 14-day, or longer, cycling periods

Moisture Trends on 1st Seven Days of Each Cycle PA02 Basement Air



Mean Daily Change in RH -- PA02

Oct 2005 -- Jan 2007

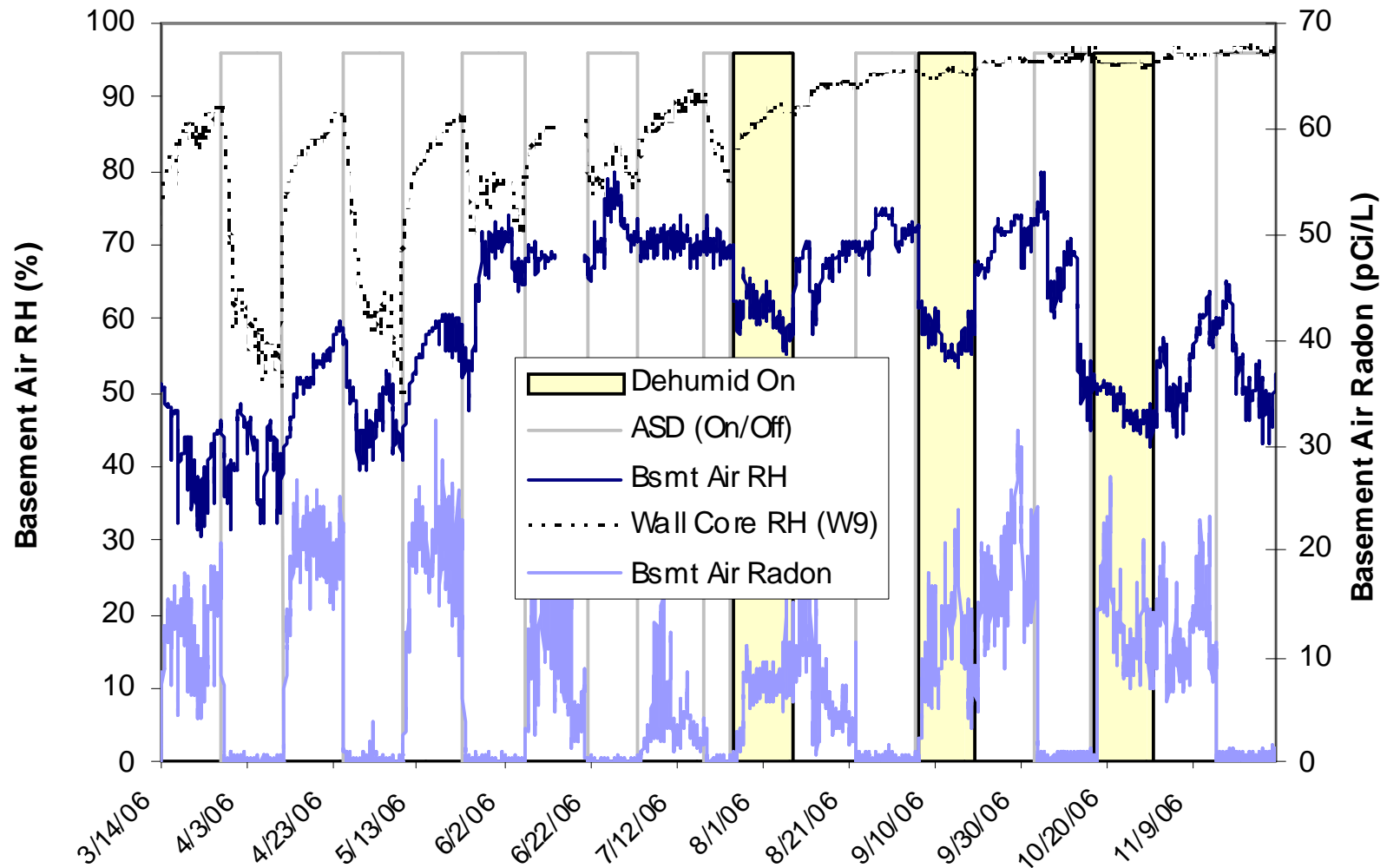


Basement Air

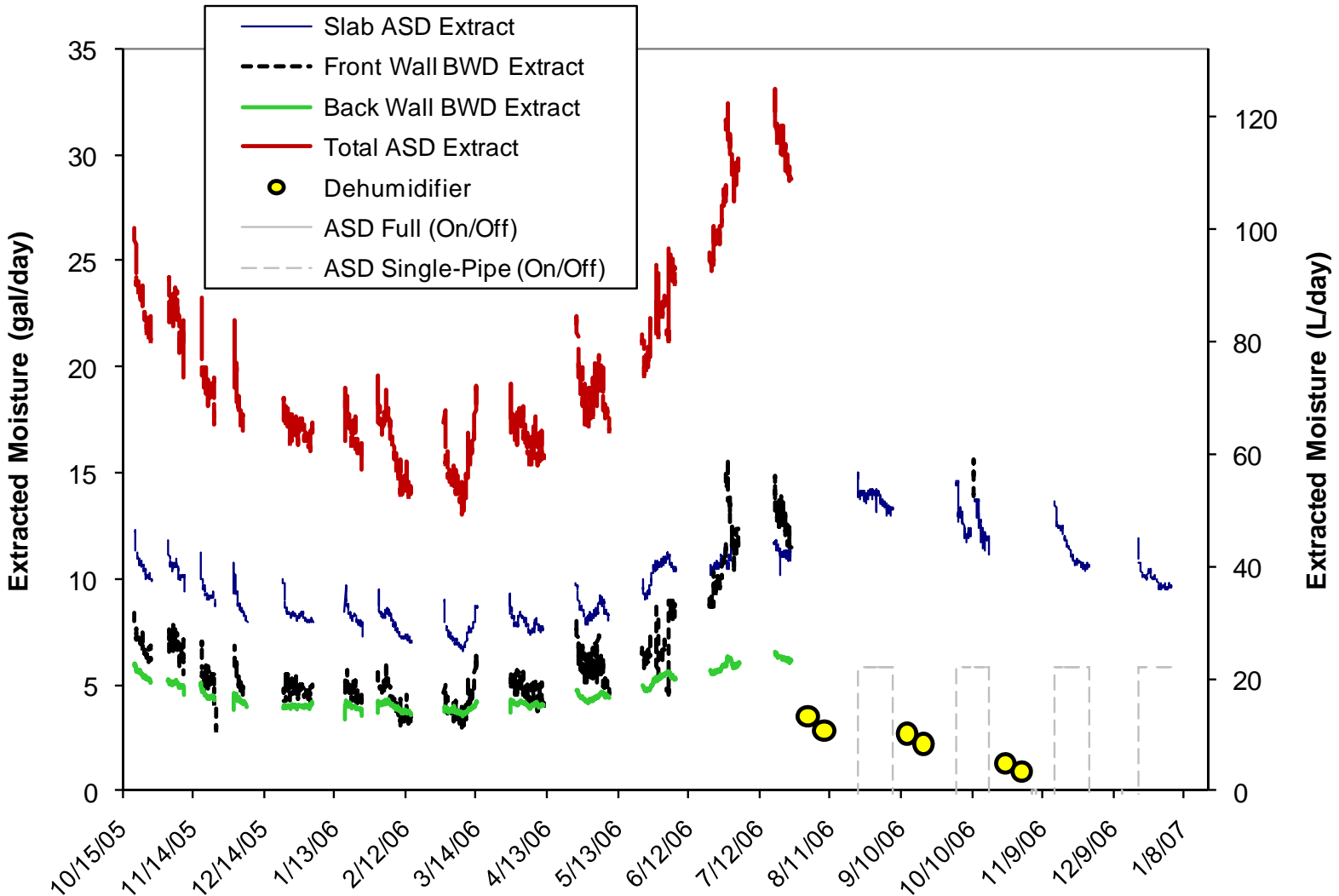
Block Walls

Slab Floor

Dehumidifier Impact in Air & Wall vs. ASD



Moisture Extraction – PA03



Moisture Extraction (gal/day)

House ID	Full System	Single Pipe	Dehumid.	% ASD Exh. from Base.
PA01				
Summer	13	10		
Non-Summer	11	--	--	46
PA02				
Summer	23	16		
Non-Summer	17	13	--	72
PA03				
Summer	27	14	2.8	
Non-Summer	18	11	1.1	72

Additional Yearly Energy Costs

House ID/ Season	Out-1 st Flr Flow Change (cfm)	Add. Heat Cost (\$)	Add. Cool Cost (\$)	Radon Fan Elec. Cost (\$)	Total Add. Cost (\$)
PA01	3.3 - 3.9	10	2	70	83
PA02	22 - 41	60	24	70	154
PA03	30 - 63	80	41	70	191
Dehumid.	--	--	--	--	180

Summary for These Houses

- During non-summer months ASD caused significant reductions of about 3 - 20% in basement moisture (and likely reduces summer dehumidification)
- ASD robustly controls radon, and may offer other IAQ benefits due to added ventilation
- Outdoor air moisture, directly and indirectly, appears to dominate ASD effects
- ASD increased (because of foundation gaps & cracks):
 - outdoor air flow into basement and upstairs (acting as an exhaust ventilation system)
 - upstairs air flow to basement
- With outdoor air moisture levels higher in summer and lower in winter, ASD has potential to both increase drying and add moisture

Summary for These Houses (cont)

- Central AC tended to dehumidify upstairs air in summer, which in turn dried the basement
- ASD applied to open core block especially effective at reducing wall moisture
- Dehumidifier tested at only one house (PA03):
 - Dehumidifier more effective controlling indoor air RH, but ASD also reduced wall moisture
 - ASD removed from 5 – 10 X more moisture than dehumidifier:
 - ASD may also be removing moisture, and drying, foundation materials and materials surrounding foundation
- ASD impact on moisture related to many factors including air leakage from outdoors, upstairs, and soil, HVAC systems, outdoor conditions, soil types

ASD Has Potential for Significant Moisture Impact, But . .

- Results of this study of 3 houses insufficient for national design & policy guidance
- ASD designed for radon control:
 - may not be optimal for all moisture concerns
 - operating characteristics may be different for other climates, seasons, and house construction and systems
- Need demonstration in other house types, climates, and soil types
- Uncontrolled exhaust ventilation can:
 - cause back-drafting of naturally aspirated combustion appliances
 - have other undesirable effects (e.g., increased energy use)
- May have other benefits:
 - Long-term operation could dry surrounding materials and soil
 - Larger moisture reductions at surfaces of walls and floors, where moisture-vulnerable materials are installed

Get the Full Reports

<http://www.epa.gov/radon/pubs/index.html>

(about the 6th publication on the list)