Kohta Ueno

Moisture Safe?

The Writings on the Wall

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

Description: As building enclosure consultants, the speakers often face questions on wall moisture issues that make us say, "Really?! We figured this out 10 or 20 years ago." Unfortunately, it seems like many of these lessons have been lost on dusty shelves or forgotten papers. We will sift through older-but-great literature, and give you takeaways on building moisture safe walls. Topics will include insulating sheathing, ventilated claddings, inward vapor drives, vapor retarder paints, and many more.

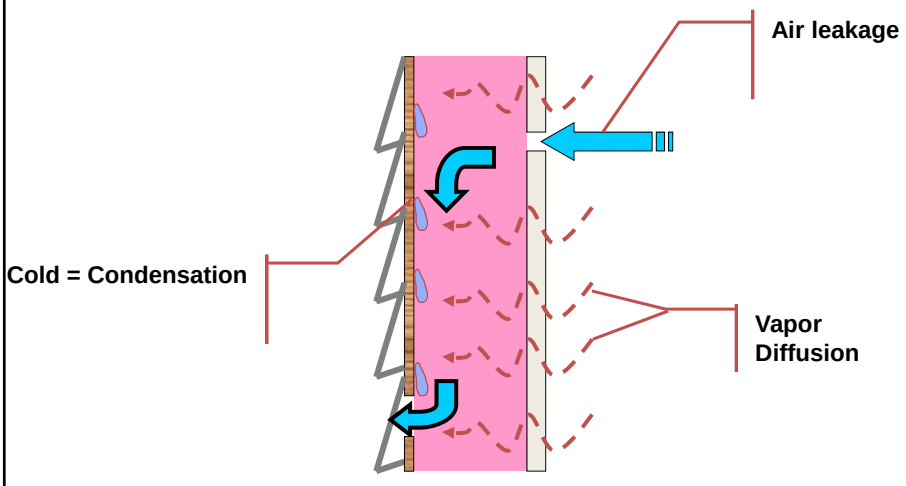
Learning Objectives

At the end of the this course, participants will be able to answer:

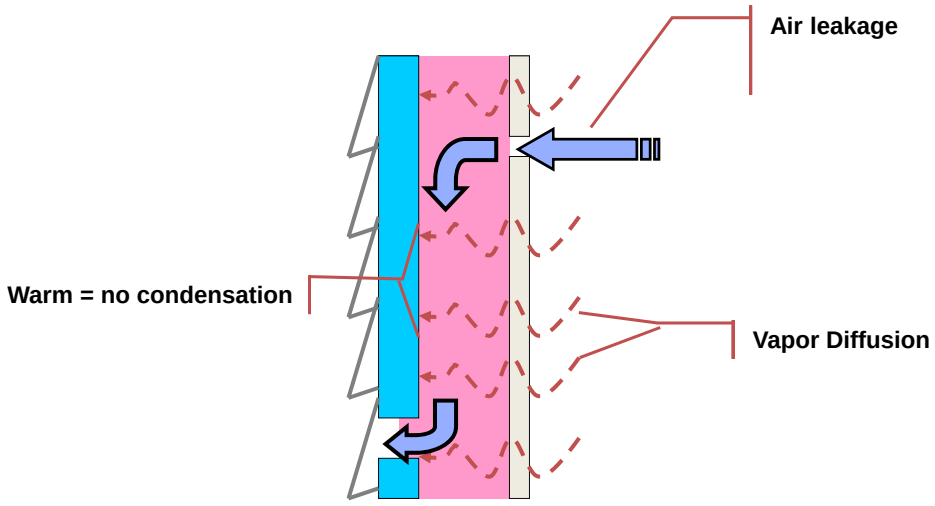
1. Explain the role of cladding ventilation in drying of assemblies
2. Calculate or estimate ratios of interior vs. exterior wall insulation to minimize condensation risks under various conditions
3. Provide details for walls to avoid issues with inward vapor drive condensation/accumulation
4. Explain the potential risks of vapor-impermeable exterior insulating sheathing, and how to control the risks

Exterior Insulating Sheathing

Wall w/o Insulated Sheathing

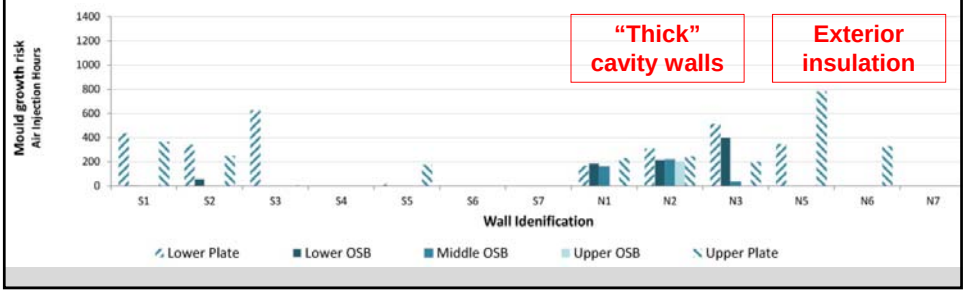


Wall with Insulated Sheathing

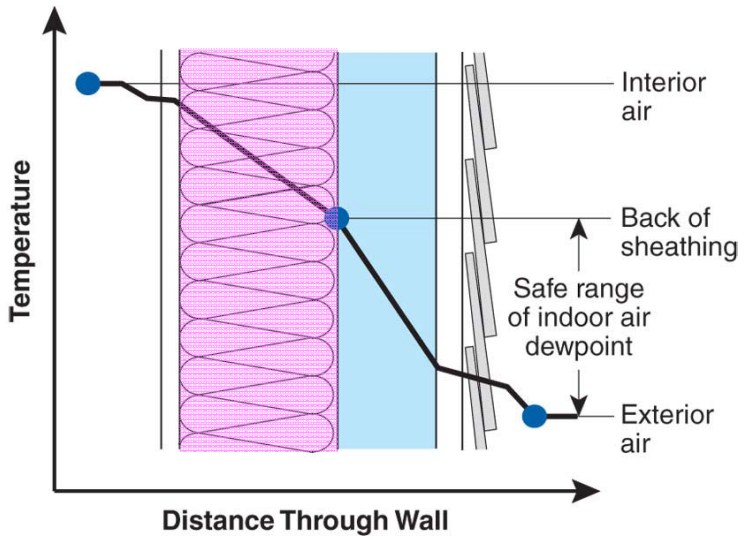


Exterior Continuous Wall Insulation

- Decades of papers: exterior insulation → drier sheathing (warm dry side)
- Fox (2014): high-R walls, air injection & drying
- Vapor-impermeable exterior rigid insulation
  - Cuts off outward drying (impermeable)
  - Reduces interior-sourced condensation risks
  - Worst case: thin vapor-impermeable foam



Ratio of Exterior-to-Interior Insulation



Code Tables-Class III (Latex Paint)

TABLE N1102.5.1
CLASS III VAPOR RETARDERS

Zone	Class III vapor retarders permitted for:
Marine 4	Vented cladding over OSB Vented cladding over plywood Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with *R*-value ≥ 2.5 over 2x4 wall Insulated sheathing with *R*-value ≥ 3.75 over 2x6 wall
5	Vented cladding over OSB Vented cladding over plywood Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with *R*-value ≥ 5 over 2x4 wall Insulated sheathing with *R*-value ≥ 7.5 over 2x6 wall
6	Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with *R*-value ≥ 7.5 over 2x4 wall Insulated sheathing with *R*-value ≥ 11.25 over 2x6 wall
7 and 8	Insulated sheathing with *R*-value ≥ 10 over 2x4 wall Insulated sheathing with *R*-value ≥ 15 over 2x6 wall

What Are the Ratios (% Exterior)?

Climate Zone	Minimum R-Value (2x4)	Minimum R-Value (2x6)	% Exterior Insulation 2x4 (±)	% Exterior Insulation 2x6 (±)
4C	2.5	3.75	16%	16%
5	5	7.5	28%	28%
6	7.5	11.25	37%	37%
7/8	10	15	43%	44%

- Original calculations & code change by BSC (Lstiburek, Straube, Schumacher)
- Ratios apply to higher-R walls (e.g., flash and batt, double stud wall)
- What happens when you “miss”? (too little exterior insulation)

UWaterloo (CZ 6A) Walls

UWaterloo (CZ 6A) Walls

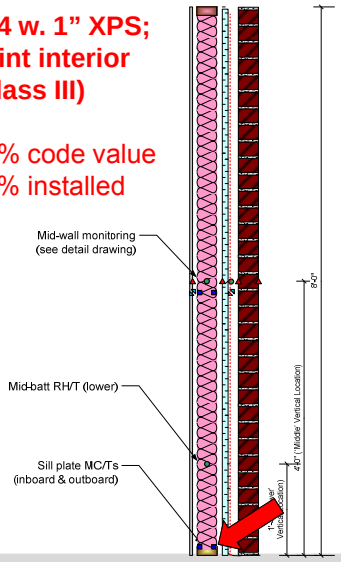
- Interior run at 68 F/50% RH year round
- Very challenging interior condition
- Walls 2x4 + XPS, 2x6 paint/poly

N1/S1=XPS, paint
N2/S2=paint
N3/S3=polyethylene

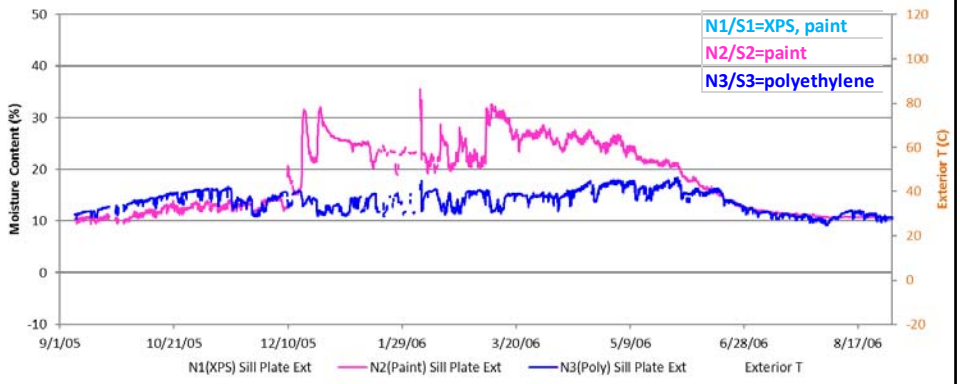
UWaterloo (CZ 6A) Walls

2x4 w. 1" XPS; paint interior (Class III)

37% code value
28% installed

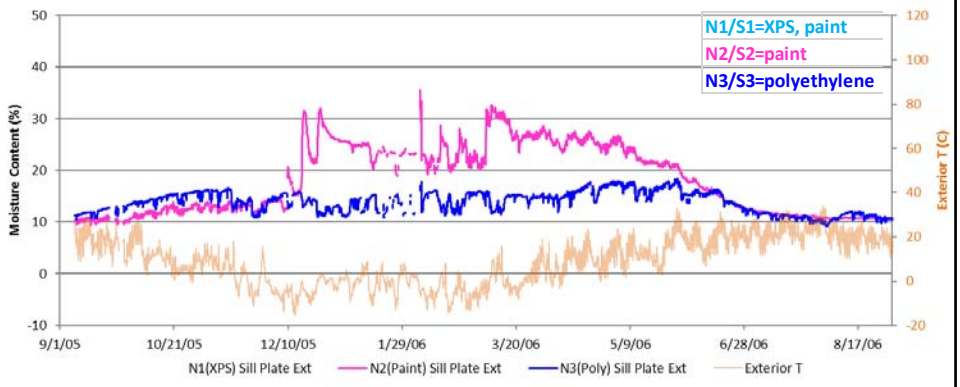


North Side Sill Plate MCs



- 20-30% MC usual “concerning” range
- XPS wall sill plate soaking wet

North Side Sill Plate MCs



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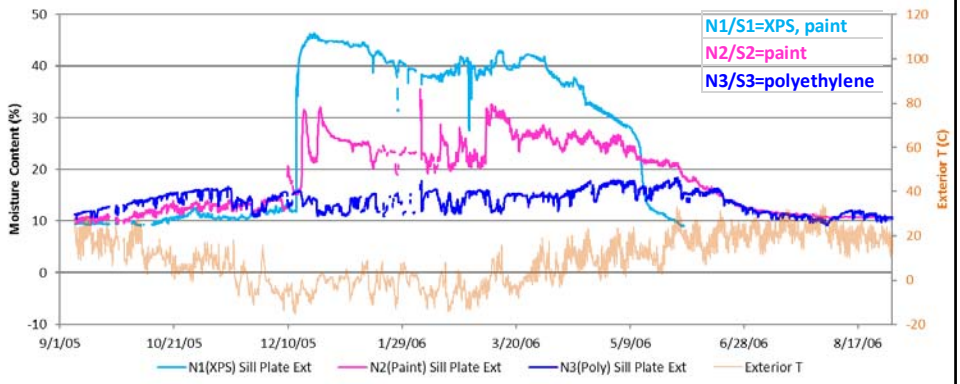


- 20-30% MC usual “concerning” range
- XPS wall sill plate soaking wet

UWaterloo (CZ 6A) Year 1 Disassembly

- Slight spotting on XPS surface
- Wetting event correlated with XPS T>32 F
- Frost accumulation followed by thaw & rundown

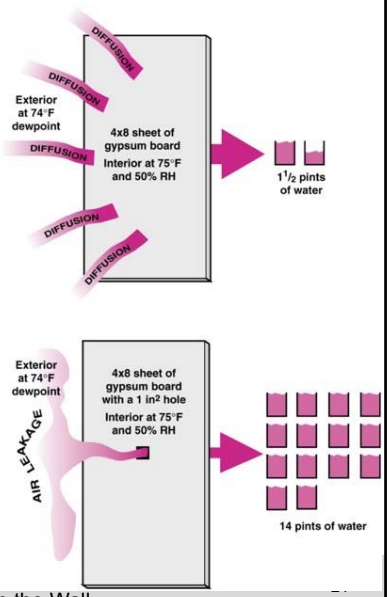
Takeaways

- Insulation ratios critical, esp. at higher int. RHs
- Foam rigid insulation is low perm
- Vapor-permeable continuous insulation even safer
- 50% RH challenging… but more realistic now

We Don't Have to Worry About Vapor… Right?

Water Vapor Transport

- Vapor Diffusion
  - more to less vapor
  - no air flow
  - flow through tiny pores
- Air Convection
  - more to less air pressure
  - flow through visible cracks and holes
  - vapor is just along for the ride



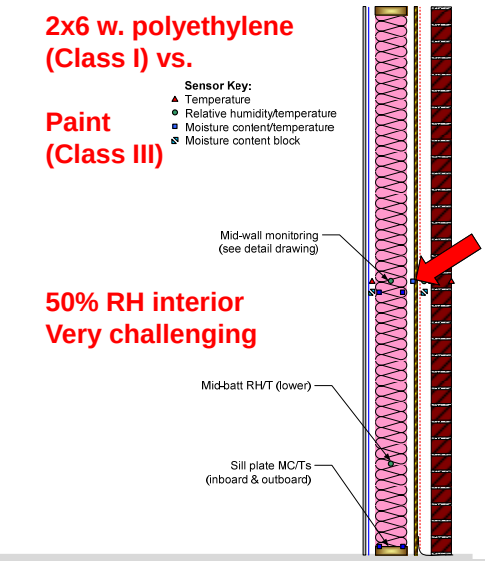
Vapor Barriers and the Code

- Class I or II required CZ 5 and higher
- Class I: 0.1 perm or less (polyethylene)
- Class II: 0.1 < perm ≤ 1.0 perm (Kraft facing, vapor retarder paint)
- Class III: 1.0 < perm ≤ 10 perm (Latex paint)

UWaterloo (CZ 6A) Walls

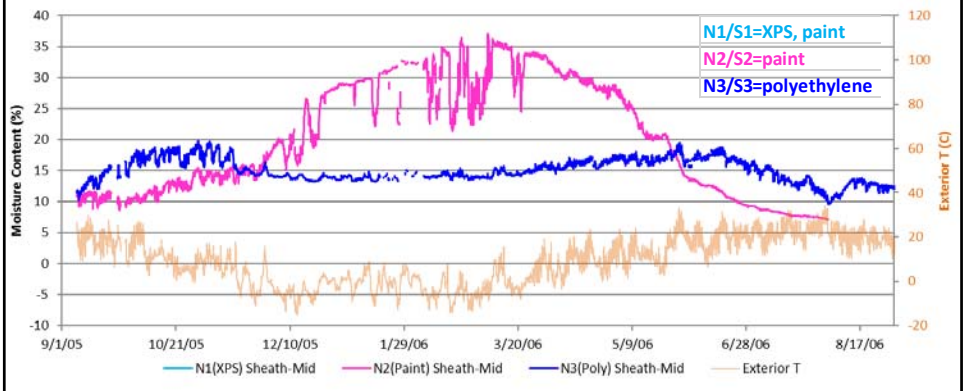
2x6 w. polyethylene (Class I) vs.

Paint (Class III)



50% RH interior
Very challenging

North Side Sheathing



- Polyethylene sheathing stayed dry through winter
- Latex paint interior—35%+ then dried down
- What did the sheathing look like?

UWaterloo (CZ 6A) Year 1 Disassembly

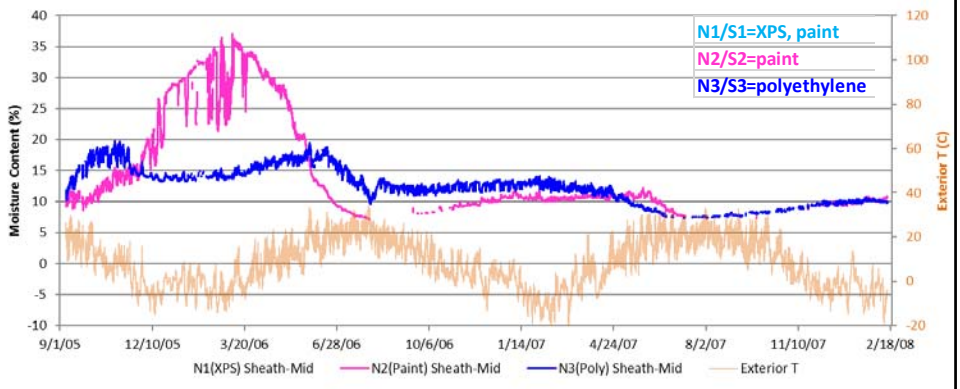
- "Paint" (no interior vapor retarder)
- Mold uniform coverage
- Worse on north than south

Vapor Retarder Paint (Class II)

Paint Perm Testing (Dry Cup)

- Vapor Barrier Paint (over existing latex)
  - *0.9-1.7 US Perms*
- Original latex paint
  - *~7-10 US Perms*
- Latex paint published:
  - *2.6-3.5 US Perms* (ASHRAE)
  - *20+ (other papers)*

North Side Sheathing



- Winter 2 (and 3): paint wall stayed drier than/as dry as polyethylene wall
- Due to stored water from summer… more later

Takeaways

- Class I (polyethylene) works… until things get wet
  - Bulk water (drying)
  - Inward vapor drives—more later
- Class II (VB paint, Kraft, SVR) works great
  - Good cold-climate recommendations in general
  - Even at challenging 50% RH interior
- Why bother with Class I (polyethylene)?
  - Air leakage must be 0.0006 in^2/ft^2 to function 0.1 perm
  - Vs. 2.5 in^2/ft^2 common airtightness #
- Vapor retarder paint on unprimed drywall?

Takeaways: Does Vapor Flow Matter?

- Big failures→air leakage
- Vapor can be the cause of failure IF
  - Wet enough interior conditions
  - Vapor open enough interior vapor control
  - Not enough seasonal drying

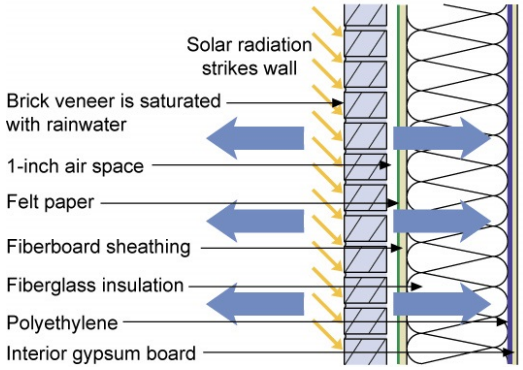
Inward Vapor Drives (Reservoir Claddings)

Inward Vapor Drive-Background

Exterior Conditions
Temperature: 80°F
Relative humidity: 75%
Vapor pressure: 2.49 kPa

Conditions within Cavity:
Temperature: 100°F
Relative humidity: 100%
Vapor pressure: 6.45 kPa

Interior Conditions
Temperature: 75°F
Relative humidity: 60%
Vapor pressure: 1.82 kPa



Vapor is driven both inward and outward by a high vapor pressure differential between the brick and the interior and the brick and the exterior.

Inward Vapor Drive

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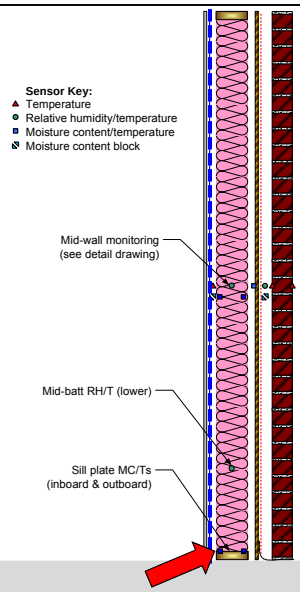
Inward Vapor Drive



- Poorly ventilated brick veneer
- Ontario Canada (6A)

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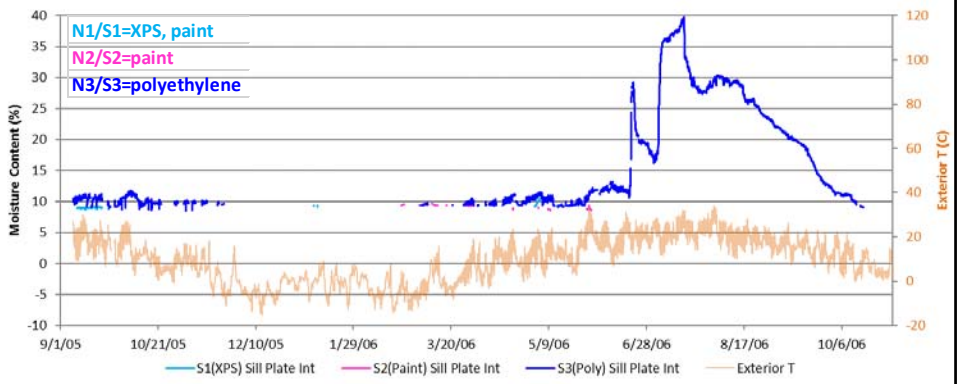
Interior-Side Sill Plate MC



- Only polyethylene wall shows problems

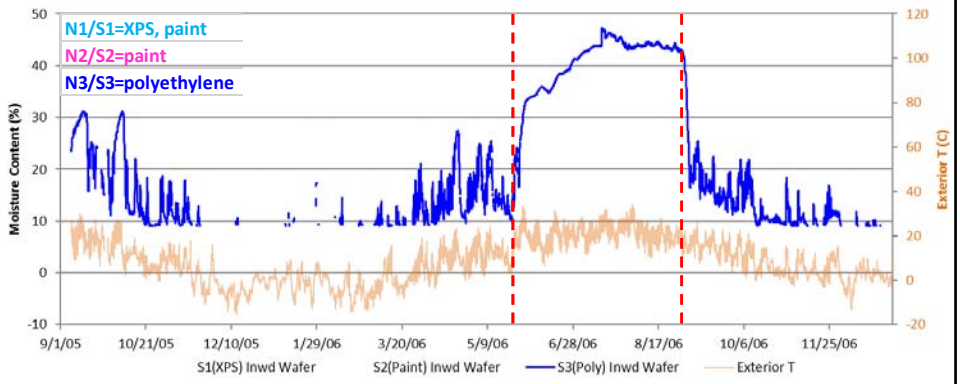
Sill Plate Wetness (September)

- Soaking wet sill plate
- Run down from polyethylene

UWaterloo (CZ 6A) VB Wafer

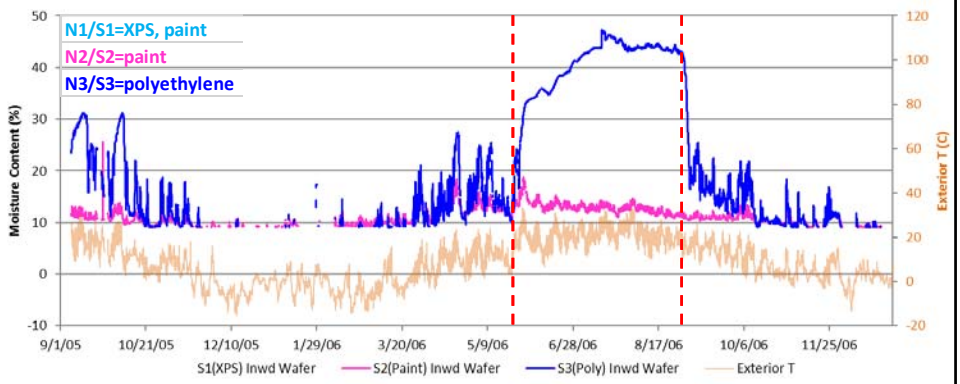
- Surrogate for relative humidity, shows moisture accumulation at interface

Fiberglass-GWB Interface Wafer MC



- Summer #1 (poorly ventilated veneer)
- Spikes & falls due to outdoor temperature
- XPS and paint walls—both fine

Fiberglass-GWB Interface Wafer MC



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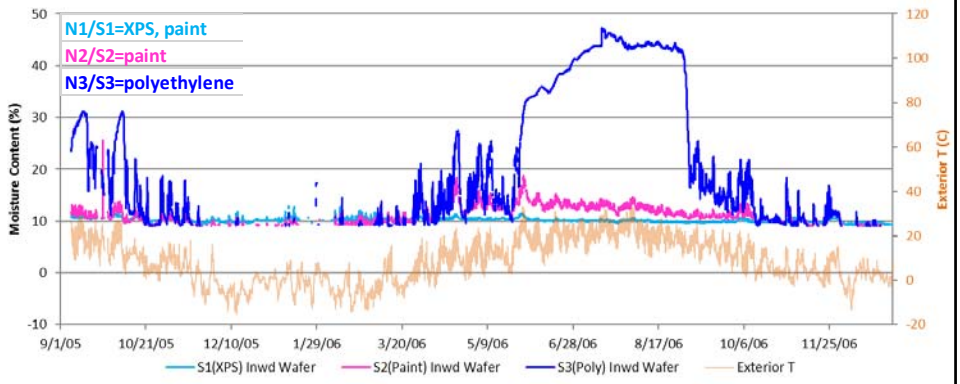
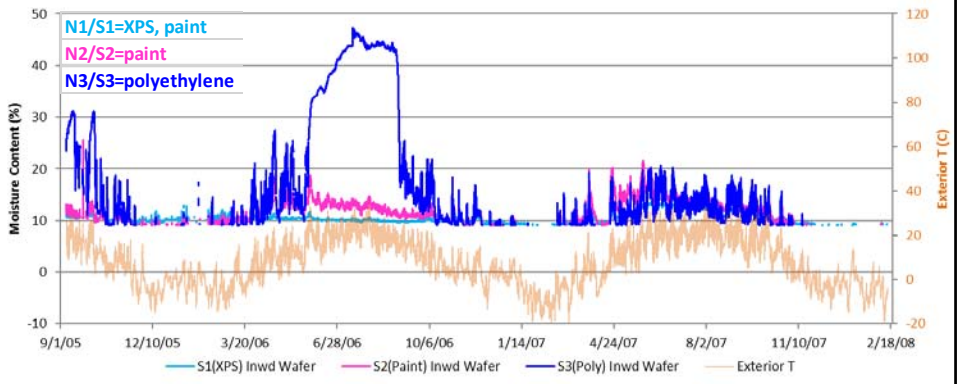


- Summer #1 (poorly ventilated veneer)
- Spikes & falls due to outdoor temperature
- XPS and paint walls—both fine

North & South Poly Wafers

Add Better Brick Ventilation (Summer 2)



- Ventilate your problems away…
- Or avoid them to begin with… (XPS)
- Summer 2: “Paint” wall is vapor retarder paint

Takeaways

- Inward drives even occur in cold climates (CZ6A)
  - With poorly ventilated veneer, polyethylene
- XPS (low perm) stops problems
- Vapor-open sheathings (DensGlass, fiberboard) increase risks
  - Permeable exterior insulation
- Stucco, adhered stone: similar potential issues
- Unintentional vapor retarders

Questions?

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This presentation will be available at http://buildingscience.com/past-events

Document Resources

- Building Science Digest 106: Understanding Vapor Barriers
  https://buildingscience.com/documents/digests/bsd-106-understanding-vapor-barriers
- Building Science Digest 163: Controlling Cold-Weather Condensation Using Insulation
  https://buildingscience.com/documents/digests/bsd-controlling-cold-weather-condensation-using-insulation
- Info-305: Reservoir Claddings
  https://buildingscience.com/documents/information-sheets/reservoir-claddings
- BA-1501: Monitoring Double-Stud Wall Moisture Conditions in the Northeast
  https://buildingscience.com/documents/bareports/ba-1501-monitor-double-stud-moisture-conditions-northeast/view
- Field Monitoring of Wall Vapor Control Strategies in the Pacific Northwest (2008)
  http://aceee.org/files/proceedings/2008/data/papers/1_8.pdf
  https://buildingscience.com/sites/default/files/Field_Monitoring_of_Wall_Vapor_Control_Strategies.pdf
- Understanding Vapour Permeance and Condensation in Wall Assemblies
  https://www03.cmhc-schl.gc.ca/catalog/productDetail.cfm?cat=151&itm=11&lang=en&sid=qxCMd3n4oxk6YDbNMKQNZ9zUZasinu4FRQToR3qpJxsaRXWFU917m0RPnadvkk2o&fr=1488303573869
- The Long and Winding Road: Remediation of ASHRAE 160
  https://buildingscience.com/sites/default/files/03.02_2015-08-05_ashrae_160_glass_schumacher_ueno.pdf