IMPROVING THE BUILT ENVIRONMENT

CARB

Moisture Monitoring in Exterior Walls

EEBA's Excellence in Building Conference 2012

Lois B. Arena
Steven Winter Associates, Inc.

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Overview of Presentation

- Building America Resources
- Reasons for Research
- Moisture Transport Basics
- Research Overview
- Results to Date
- Recommendations

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Industry Research Teams

BA-PIRC

BARA

BUILDING AMERICA RETROFIT ALLIANCE

ARIES Collaborative

Alliance for Residential Building Innovation

NorthernSTAR

CARB

Consortium for Advanced Residential Buildings

bsc Building Science Corporation

IBACOS

| Home Quality + Performance |

NAHB RESEARCH CENTER

PARR

The Partnership for Advanced Residential Retrofit

Building America Innovations

1. Advanced Technologies & Practices
2. House-as-a-System Business Case
3. Effective Guidance and Tools
4. Infrastructure Development

This research is paving the way for key innovations:

- Building Science Solutions
- Assured Health & Safety
- High Performance Home Solutions
- Research Tools
- Informing Codes & Standards

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CARB's Builder Resources

- Technical report: Optimization of Wall Assemblies can be found at http://www.carb-swa.com/
- Builder guide: Mold: Ignorance is not Bliss can be found at http://www.carb-swa.com/articles/guidelines/Mold%20writeup.pdf
- Vapor Retarder requirements: Table 601.3.1 2009 IRC/702.7.1 2012 IRC
- ASHRAE Standard 160: Criteria for Moisture-Control Design Analysis in Buildings
- ASTM MNL 18 & ASTM MNL 40 – deal with moisture in building envelopes
- ENERGY STAR® Water Management Guidelines http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_v2_v3_training_resources#checklist Technical references
- More DOE resources: www.buildingamerica.gov

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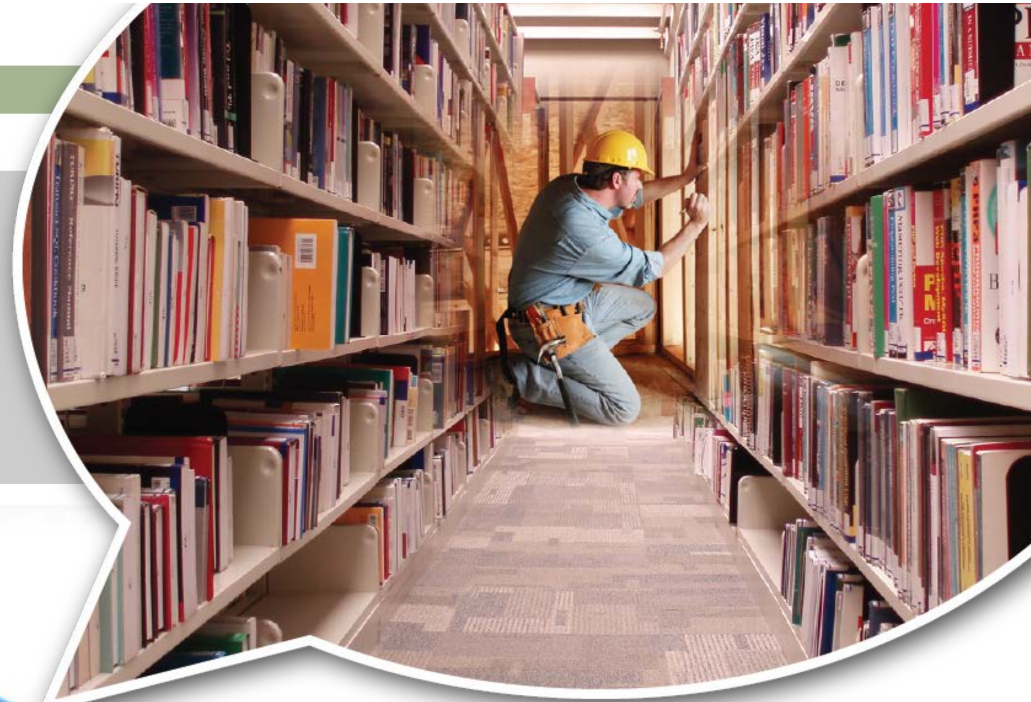
COMING IN JANUARY



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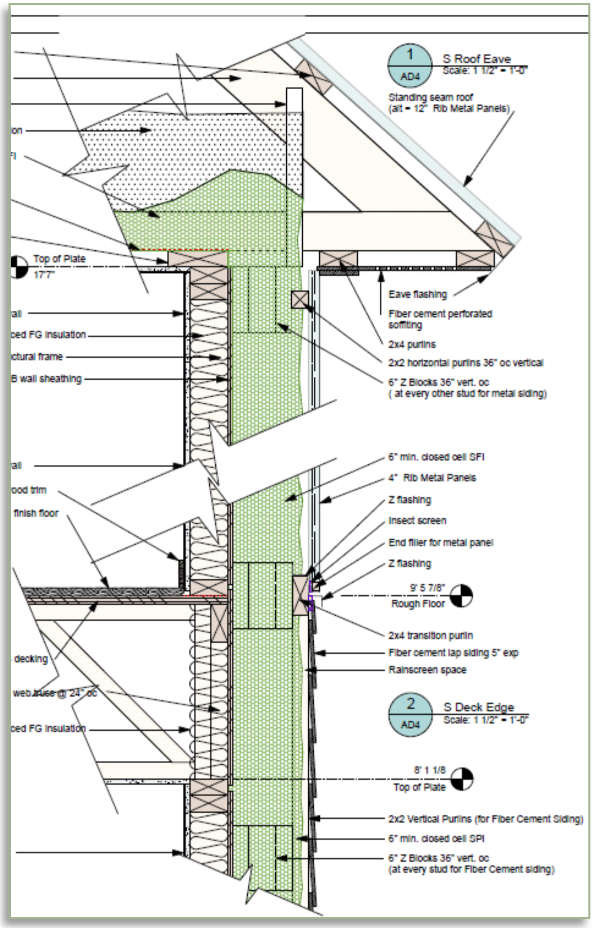
Reasons for Research

- Changes in construction due to:
  - Drastic increase in retrofit activities
  - Programs like PH & NZEH challenges
  - Increased use of hybrid insulation strategies
  - New insulation products
  - Code changes



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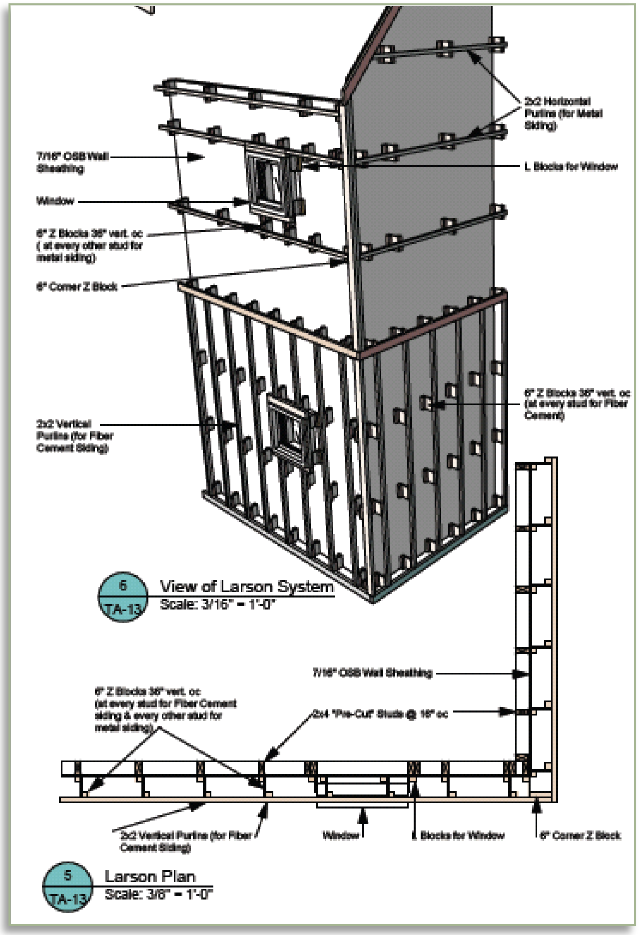
Reasons for Research

- Changes include:
  - Increased use of foam insulation
  - Increasing thickness & R-value of walls
  - Increased use of hybrid insulation strategies
  - Changes in vapor retarder/barrier strategies



Project Summary

- Evaluate potential for moisture problems in 3 new wall assemblies
- Modeling – this year
  - WUFI
  - THERM
- Field Monitoring – beginning 2012
  - Brick rehab
  - High-R walls: R-40 & 60
  - Code walls: hybrid insulation w/ spray foam & fiberglass

2nd Law of Thermodynamics

. . . processes occur in a certain direction.

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Why do we care about the 2nd Law?

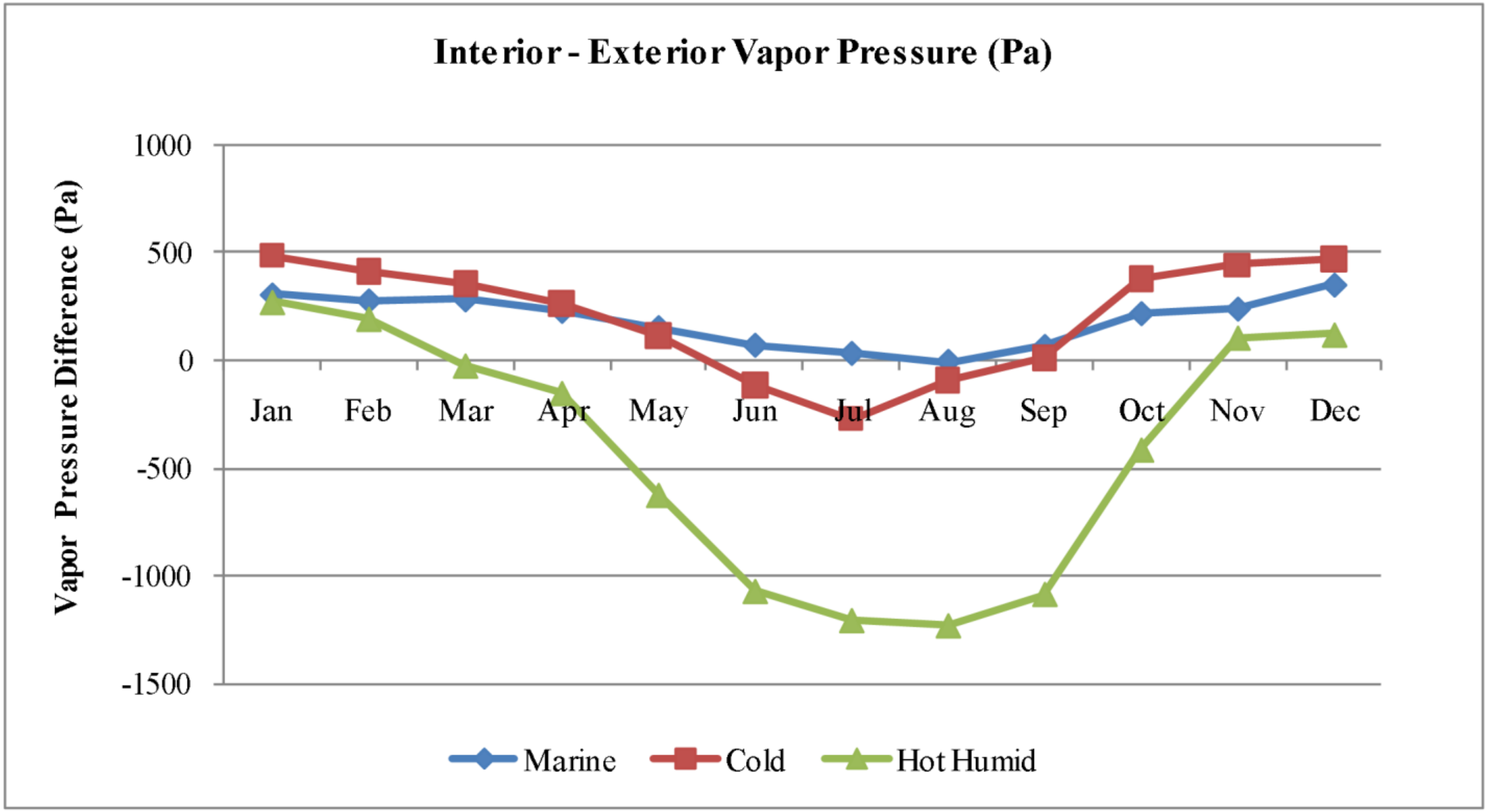
It applies to:

- How air moves
- How heat is transferred
- How moisture migrates

What you need to know most about the 2nd Law…

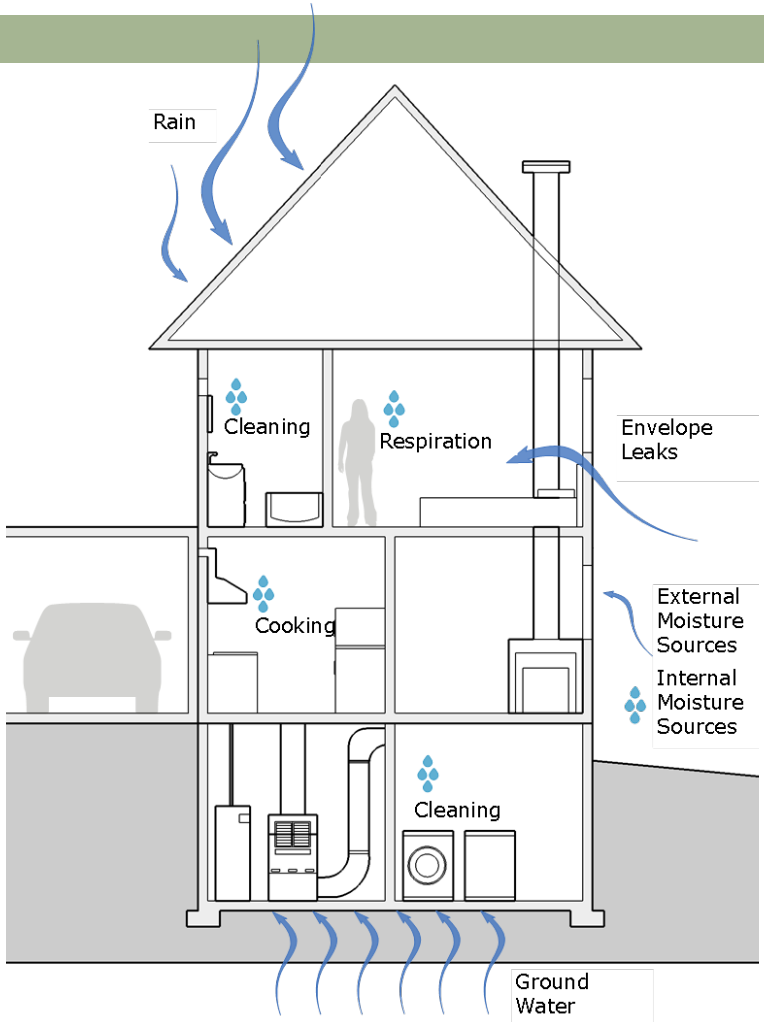
- Heat moves to cold
- Air moves from high pressure to low pressure
- Moisture moves from higher concentrations to lower concentrations

Vapor Pressure Analysis



Moisture In Buildings

- Common Moisture Sources
  - Bulk Moisture (leaks)
  - Water Vapor
    - Cooking
    - Cleaning
    - Respiration
  - Ground Water (through basement floors and walls)



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Moisture Transport

- Moisture moves around buildings in all of the following ways:
  - Bulk moisture transfer (including capillary action through porous materials)
  - Diffusion
  - Airborne moisture movement

- Which one do you think causes the most problems in homes?

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Airborne Moisture

- #1 moisture-related problem for building science professionals
- Moisture gets into attics by stack effect (how else?)
- Moisture gets into walls by:
  - Pressurization in heating season
  - Depressurization in cooling season

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Moisture Transport

Moisture Transport

Moisture Transport

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Moisture Problems in Dry Climates?

- **June 2006 Energy Design Update Article:"In Arizona, White Roofing Causes Wet Insulation"**
  - Truss uplift
  - Wet insulation
  - Mold

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Research Focus

- Assemblies
  - Brick walls with interior insulation;
  - Super insulated walls at least 12” thick: R-40 and R-60;
  - Code built walls using spray foam insulation and fiberglass w/ <u>Class III vapor retarder</u>

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Vapor Retarder Classes

- Class III: 1.0 < perm <=10 perm (latex paint)
- Class II: 0.1 < perm <=1.0 perm (kraft facing)
- Class I: < =0.1 perm (sheet polyethylene)

Class III Vapor Retarder Requirements

Climate Zone	IRC 2009 Table R601.3.1	IRC 2012 Table R702.7.1 (not listed)
Marine 4	Vented Cladding over OSB VC over PW VC over FB VC over gypsum Insulating Sheathing>=R2.5 for 2x4 IS >= R3.75 for 2x6	~~VC over OSB~~ ~~VC over PW~~ VC over WSP VC over FB VC over gypsum IS >=R2.5 for 2x4 IS >= R3.75 for 2x6
5	VC over OSB VC over PW VC over FB VC over gypsum IS >=R5 for 2x4 IS >= R7.5 for 2x6	~~VC over OSB~~ ~~VC over PW~~ VC over WSP VC over FB VC over gypsum IS >=R5 for 2x4 IS >= R7.5 for 2x6
6	VC over FB VC over gypsum IS >=R7.5 for 2x4 IS >= R11.25 for 2x6	VC over FB VC over gypsum IS >=R7.5 for 2x4 IS >= R11.25 for 2x6
7	IS >=R10 for 2x4 IS >= R15 for 2x6	IS >=R10 for 2x4 IS >= R15 for 2x6

Class III Vapor Retarder Requirements

% of total R-value is very important!

Climate Zone	IRC 2009/2012	
	% of Total R-value	Class III VR
Marine 4	16% 17%	R2.5 for 2x4 R3.75 for 2x6
5	28% 30%	R5 for 2x4 R7.5 for 2x6
6	37% 39%	R7.5 for 2x4 R11.25 for 2x6
7	44% 46%	R10 for 2x4 R15 for 2x6

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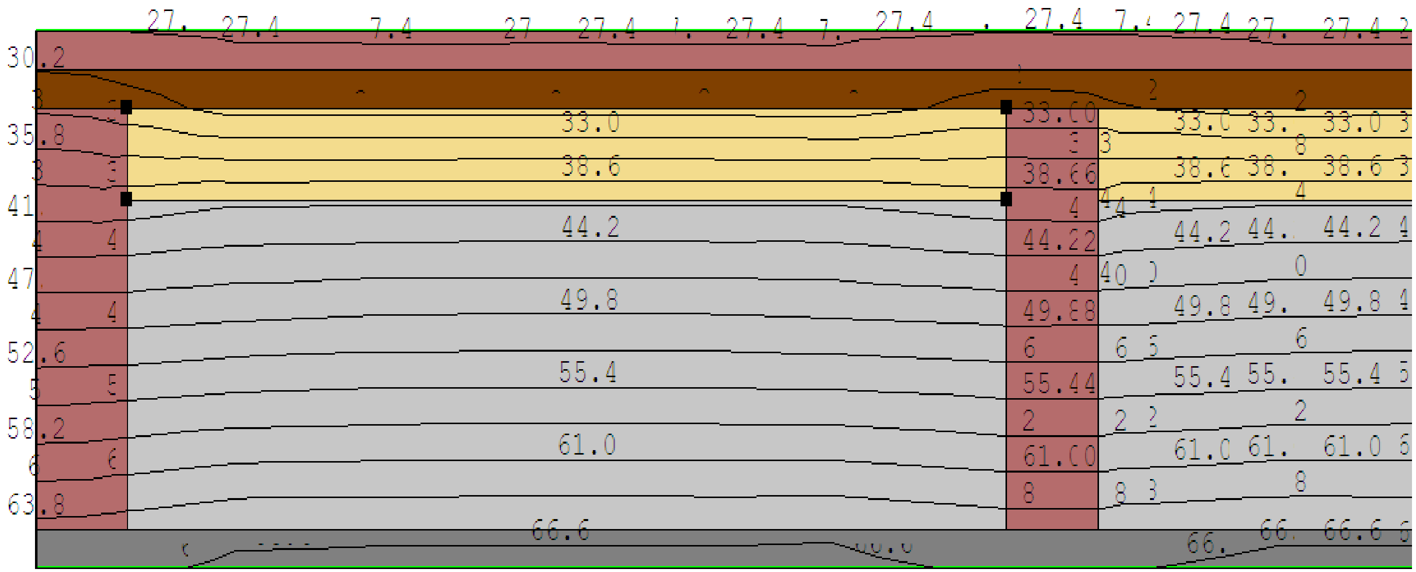
Class III Vapor Retarder Requirements



Vapor Retarder Requirements

Climate Zone	IRC 2009		IRC 2012	
	Insulation	Class III VR	Insulation	Class III VR
Marine 4	20 or **13+5**	R2.5 for 2x4 R3.75 for 2x6	20 or **13+5**	R2.5 for 2x4 R3.75 for 2x6
5	20 or **13+5**	R5 for 2x4 R7.5 for 2x6	20 or **13+5**	R5 for 2x4 R7.5 for 2x6
6	20 or 13+5	R7.5 for 2x4 R11.25 for 2x6	20+5 or **13+10**	R7.5 for 2x4 R11.25 for 2x6
7	21	R10 for 2x4 R15 for 2x6	20+5 or **13+10**	R10 for 2x4 R15 for 2x6

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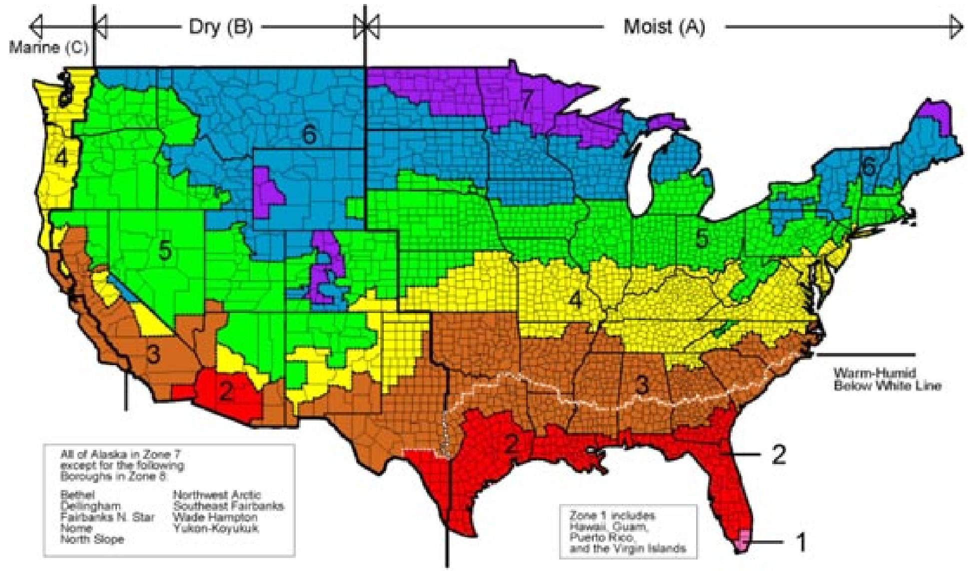
Research Focus

- Climate zones 4 through 7
  - experience both cooling and heating seasons
  - considerable humidity during the summer



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Questions to be Answered

- How does WUFI modeling compare to actual monitored moisture levels in the three assemblies?
- Are the R-values specified in Table 601.3.1 of the 2009 IRC sufficient to prevent condensation?

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Technical Approach

- Modeling w/ WUFI & THERM
- Field testing – moisture content of components at start of construction
- Long term monitoring – moisture levels, RH & temperature at various points in the walls
- Comparison of modeling & field data
- Evaluate against accepted failure criteria

Modeling - THERM

- WUFI can only analyze continuous components
- Want to analyze condensation potential due to thermal bridging at framing members - THERM

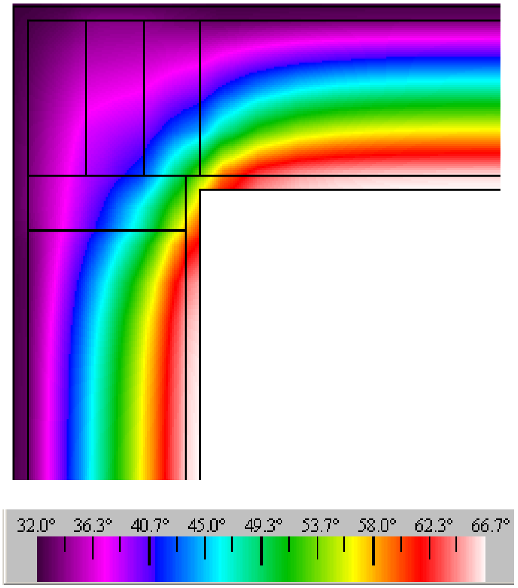

Image from THERM

Field Testing – just starting

- Short Term
  - moisture content of components using a hand held moisture meter
  - Adjust values in WUFI if necessary
- Long Term
  - RH & Temp at critical interfaces
  - Moisture content – OSB, brick, studs
  - Climatic conditions

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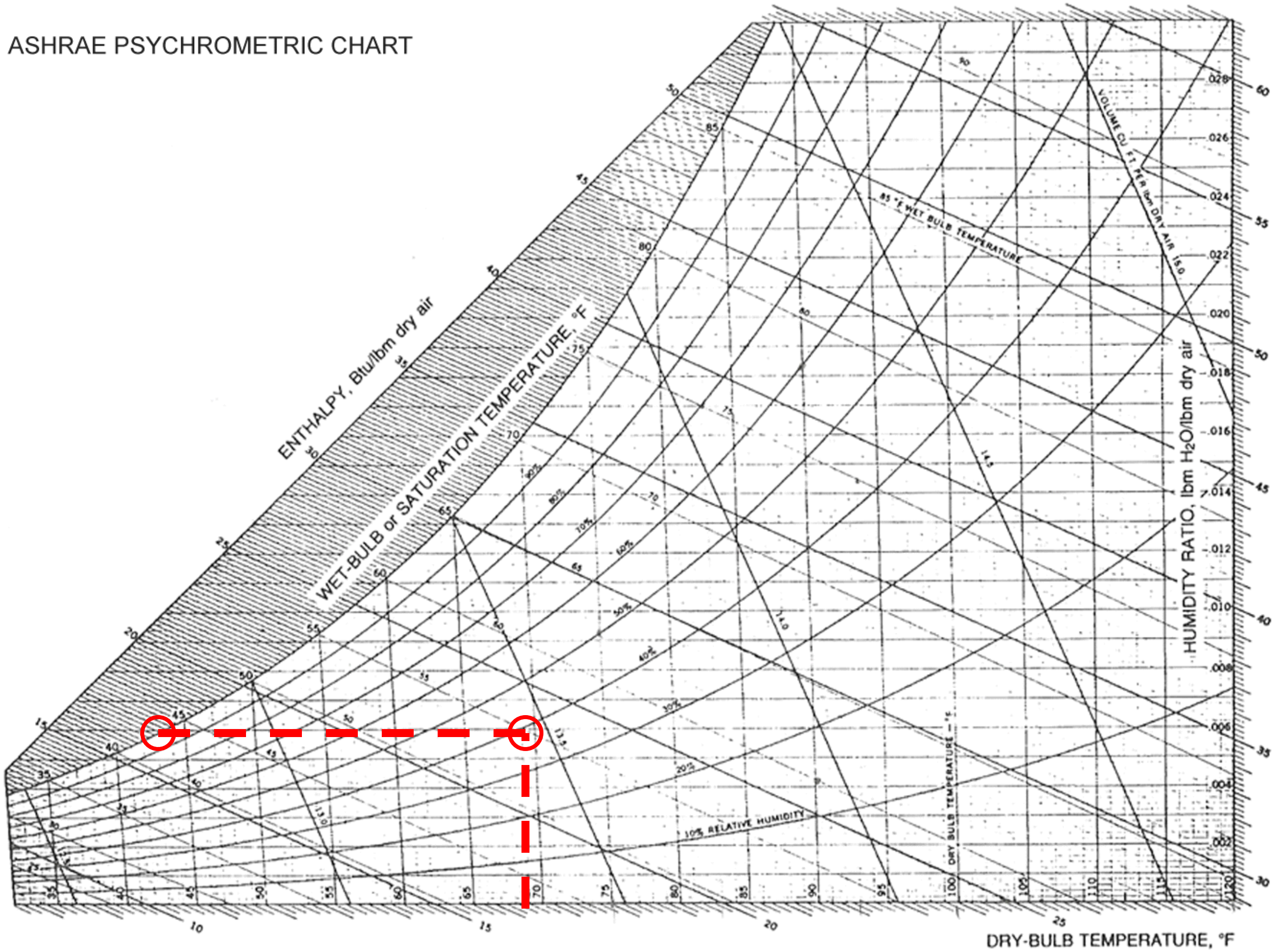
Failure Criteria

- Moisture Content (MC)
- Condensation
- Mold growth
- Critical water content
- Freeze-thaw cycles

MC & Condensation Potential

- Moisture Content (MC) of OSB < 20%
- Condensation Potential – graph interior air dew point temp vs. surface temp
  - Several interfaces will be analyzed – OSB/foam, foam/cavity insulation, interior surface of brick
  - THERM – framing/OSB, framing/insulation

Finding Dewpoint



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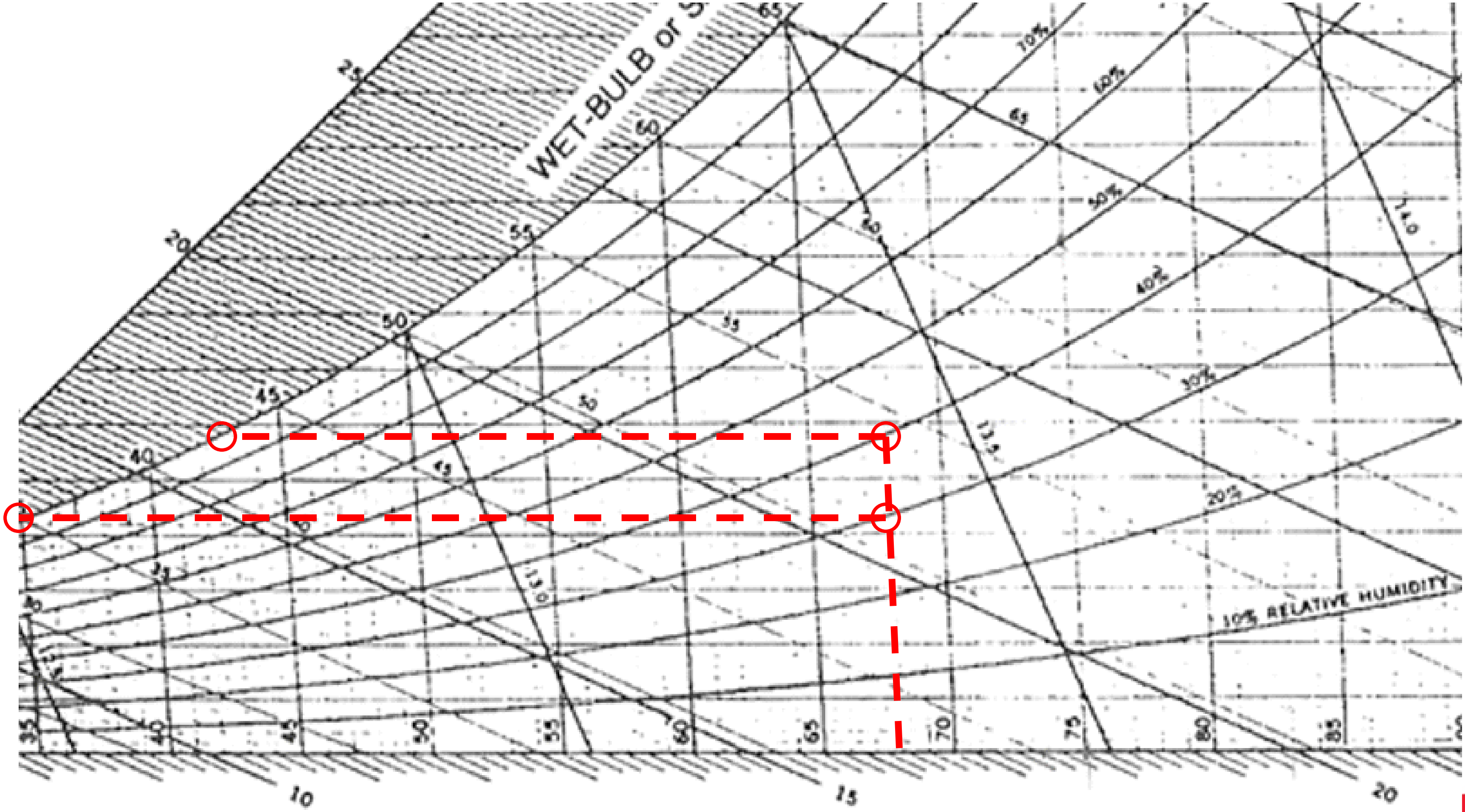
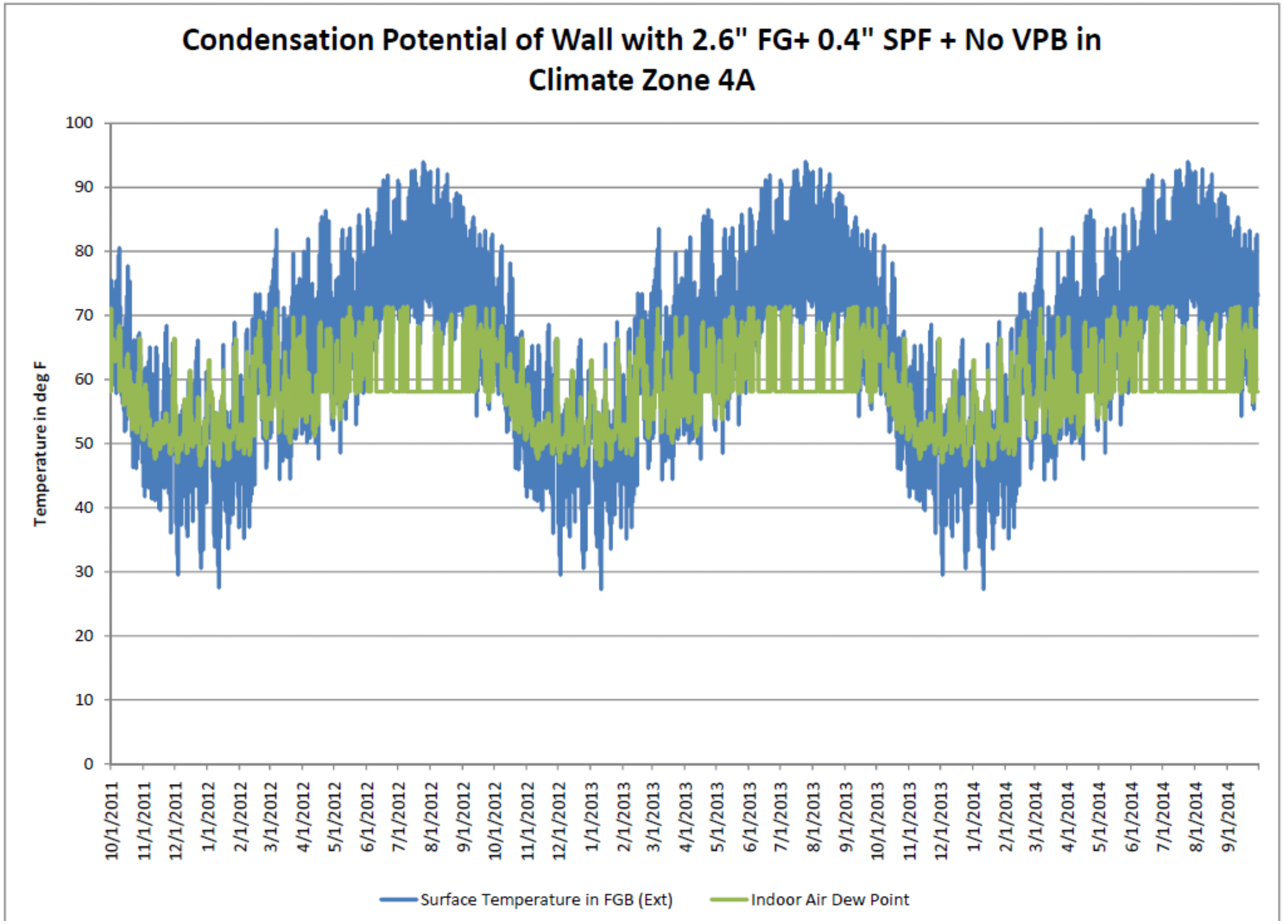
Finding Dewpoint



Condensation Potential



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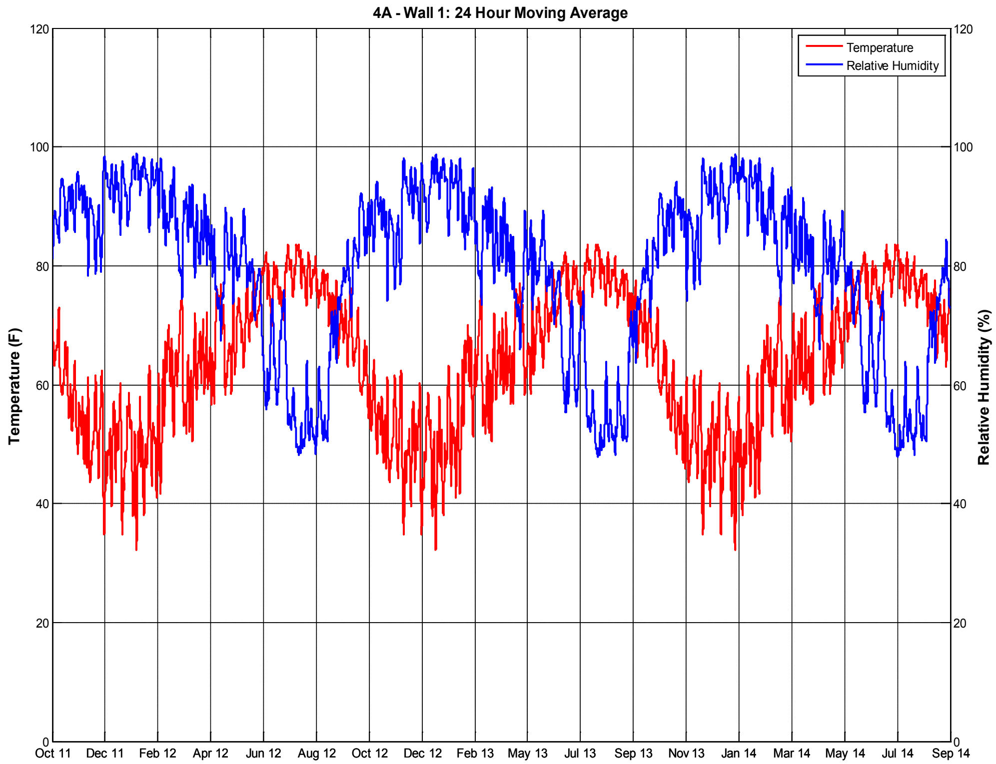
Mold Growth

- ASHRAE Standard 160 performance criteria:
  - 30–day running average: surface RH<80% & temp 41°F to 104°F



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Freeze-Thaw Damage

- Two factors influence frost damage
  - MC on freezing – critical level for brick 90%
  - Number of freeze thaw cycles – higher number of cycles, more potential for freeze-thaw damage

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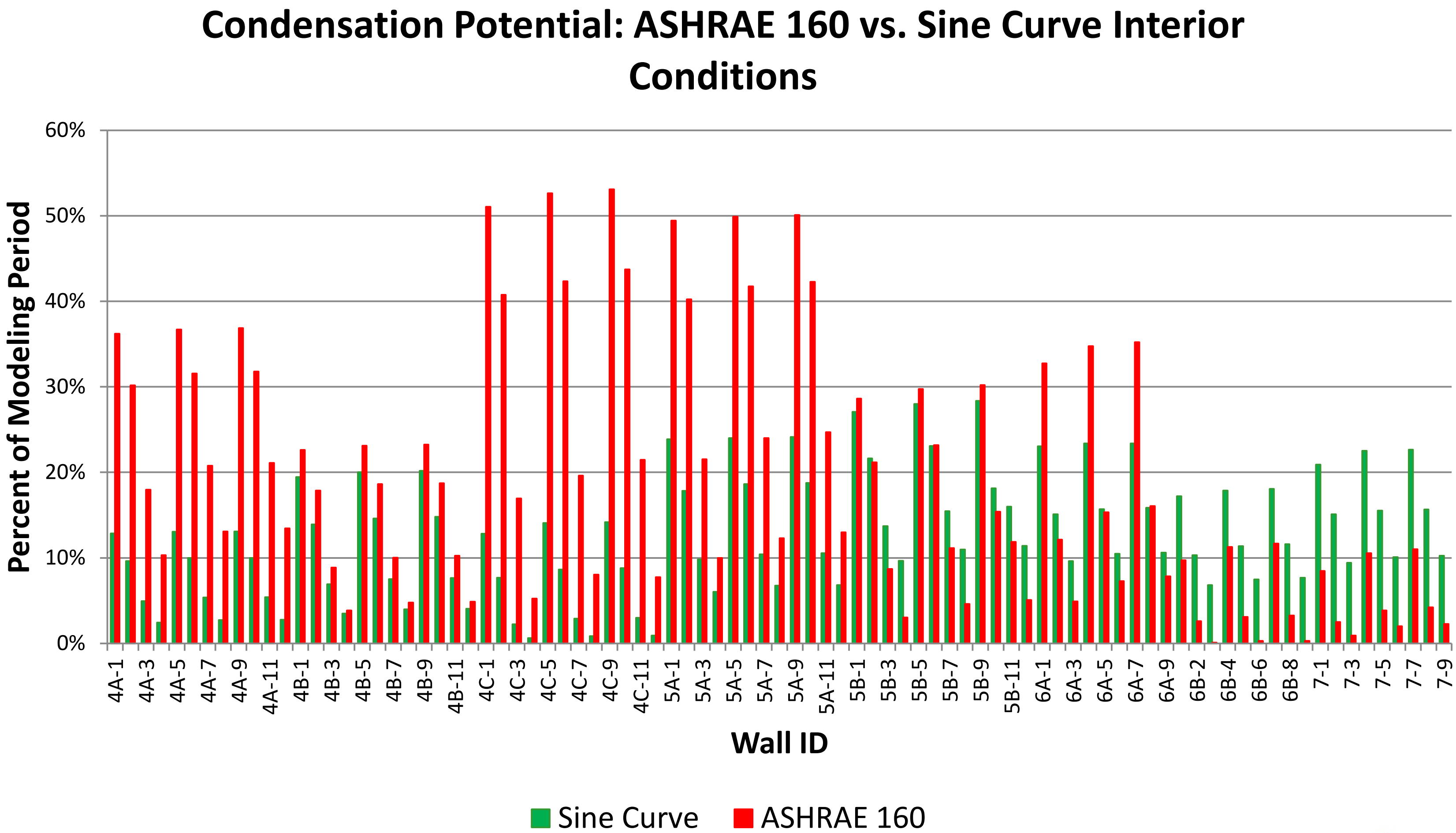
Results – Code hybrid



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Results – Code hybrid

Climate Zone	Climate File	Average Outdoor Temperature	Average Dew Point Temperature (Dec., Jan., Feb.)	Interior Surface of MDSPF	Stud Temperature at Interior Surface of MDSFP
		[°F]	[°F]	[°F]	[°F]
4A	Nashville, TN	38	51	**46**	**46**
4B	Albuquerque, NM	37	45	46	46
4C	Seattle, WA	41	52	**48**	**48**
5A	Detroit, MI	27	45	**42**	**40**
5B	Elko, NV	27	45	**42**	**41**
6A	Madison, WI	18	42	**41**	**39**
6B	Billings, MT	27	43	46	44
7	Intl. Fall, MN	6	39	41	38

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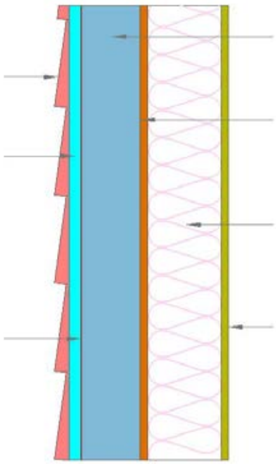
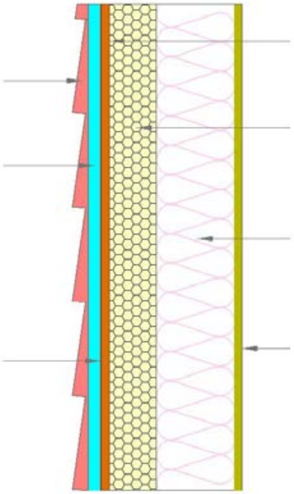
Results – Code hybrid

	Sine Wave - (69.8 ± 1.8°F, 50% RH ± 10%)						ASHRAE 160 - Cooling Assumed					
	ASHRAE Criteria	OSB Moisture Content	Assembly Moisture Content	Isopleths Interior	Isopleths MDSPF	Condensation Potential	ASHRAE Criteria	OSB Moisture Content	Assembly Moisture Content	Isopleths Interior	Isopleths MDSPF	Condensation Potential
4A-1	X	√	√	√	X	13%	X	√	√	X	X	36%
4B-1	X	√	√	√	X	19%	X	√	√	√	X	23%
4C-1	X	√	√	√	X	13%	X	X	√	X	X	62%
5A-1	X	√	√	√	X	24%	X	√	√	X	X	49%
5B-1	X	√	√	√	X	27%	X	√	√	√	X	29%
6A-1	X	√	√	√	X	23%	X	√	√	X	X	33%
6B-1	X	√	√	√	X	17%	X	√	√	√	X	10%
7-1	X	√	√	√	X	21%	X	√	√	X	X	8%

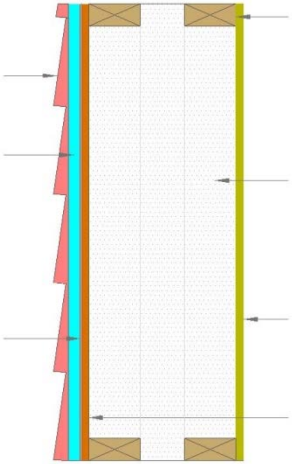
Results – High R-value



Exterior Rigid



Spray Foam



Double Stud Cellulose

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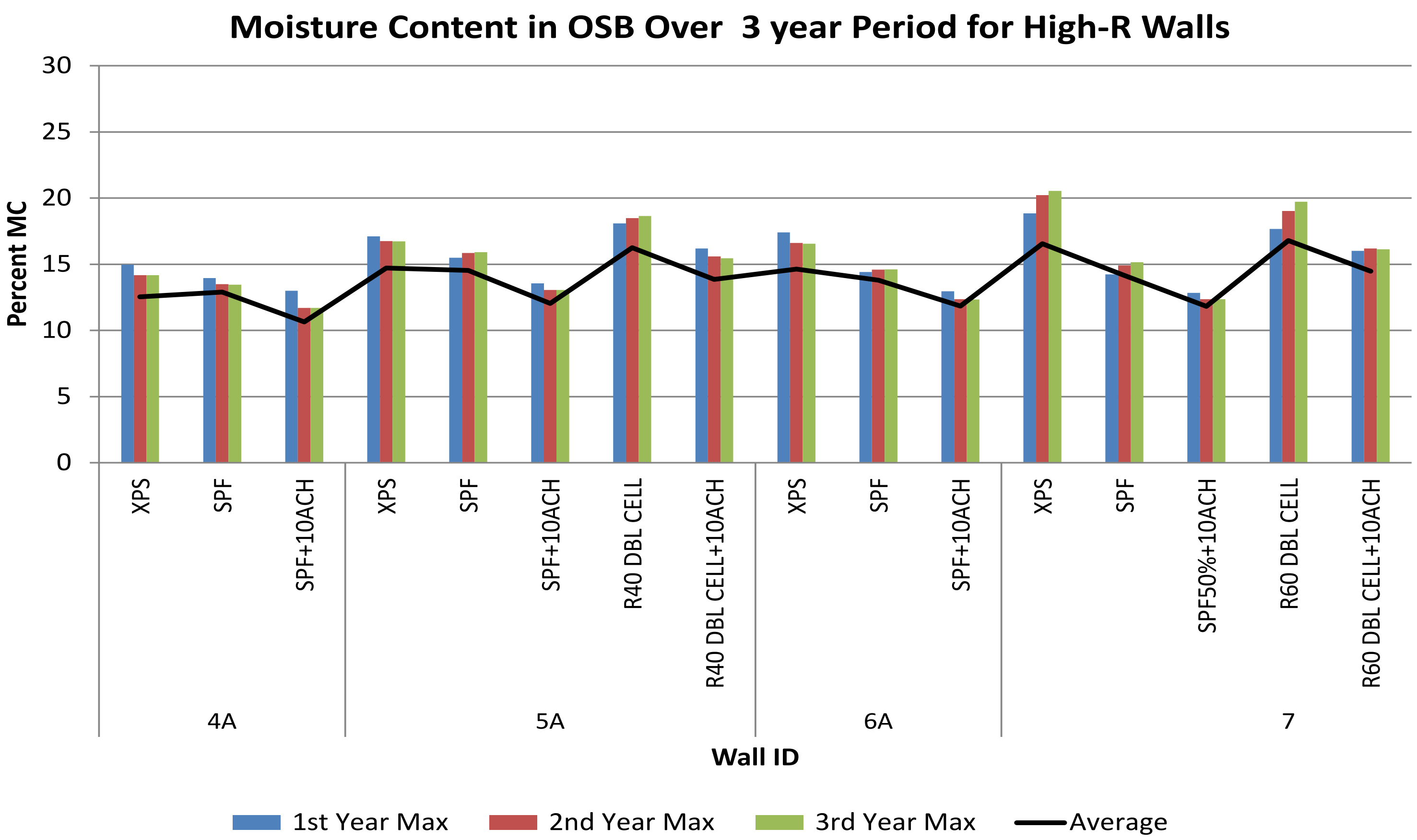
Results – High R-value



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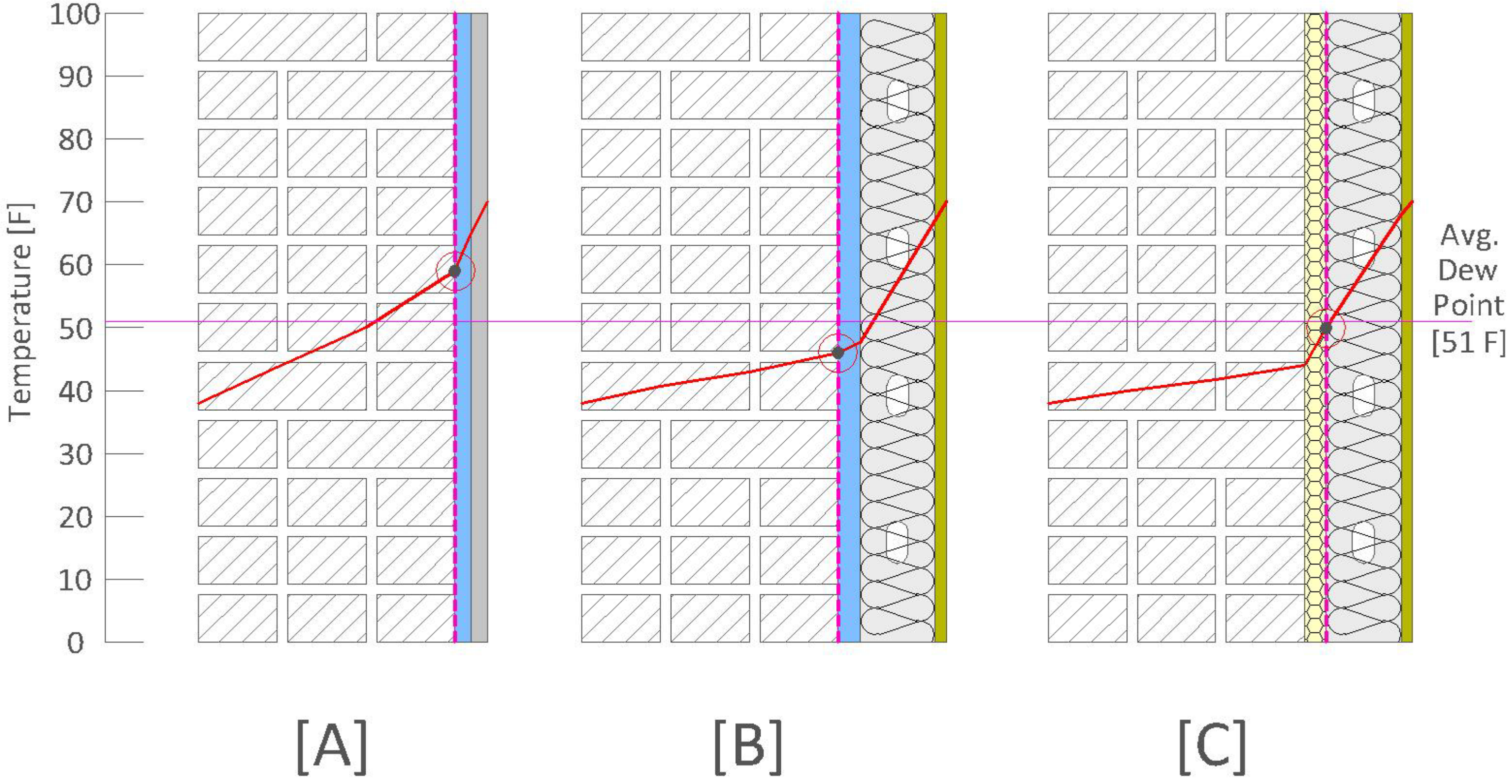
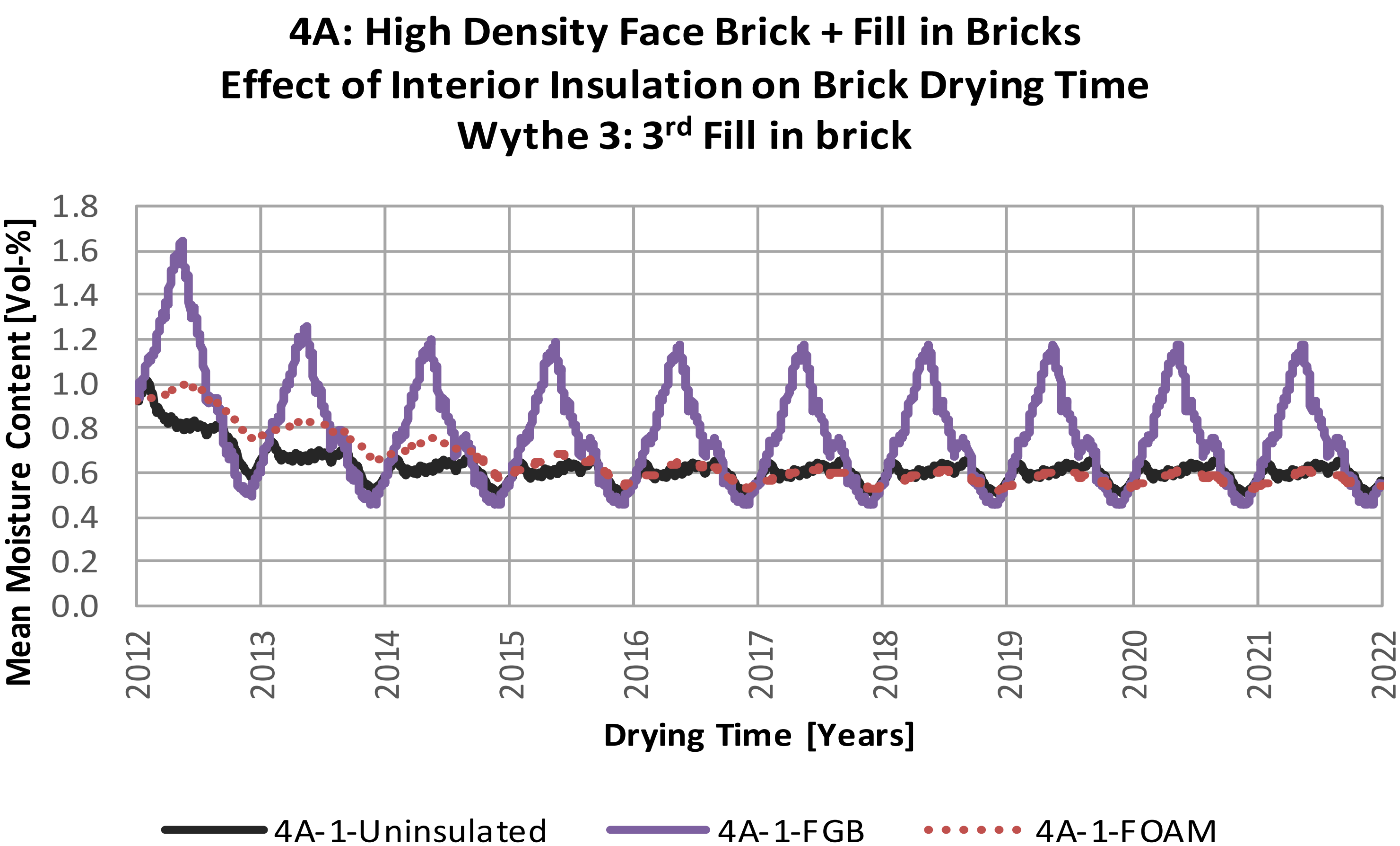
Results - Brick



Results - Brick



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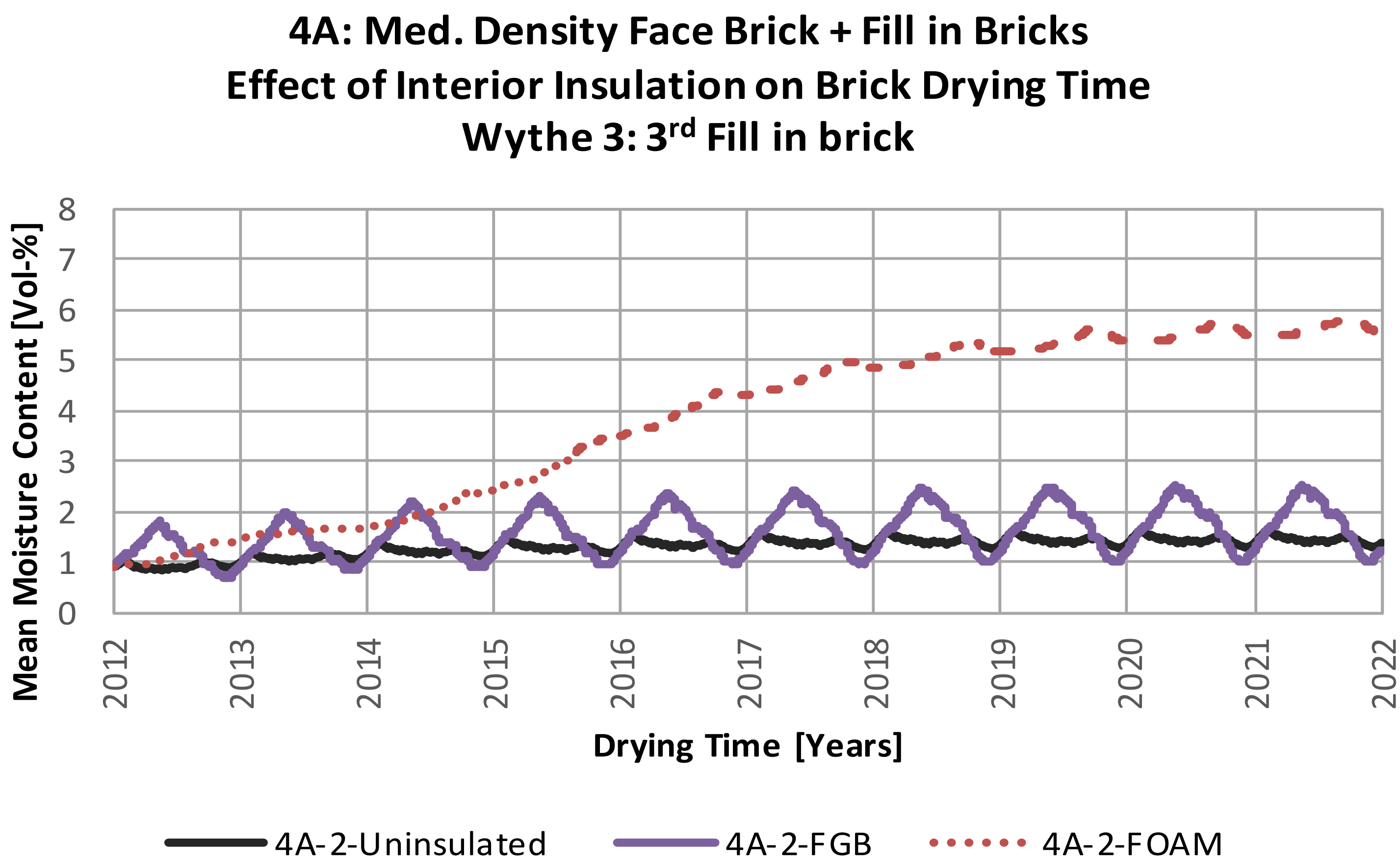
Results - Brick



Recommendations

- Do NOT use code minimums for exterior rigid or spray foam for high-R walls (look at RATIOS!)
- If you have unusual materials or conditions - use WUFI and THERM to evaluate your projects on a case by case basis
- Evaluate the climate conditions for your project carefully and compare to software assumptions
- Must prevent interior moisture from getting into the walls
- Vented cladding is recommended for high-R walls when exterior rigid insulation is not part of the wall system

Recommendations

- Assess condensation potential, along with other failure criteria like:
  - Mold growth potential – ASHRAE 160
  - Assembly Moisture Content
  - Freeze Thaw Damage (in masonry walls)

Questions?

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