



Air Infiltration Prevention – What the Test Results Showed

RESNET Conference

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NAHB Research Center

Dedicated to improving home building since 1964.



NAHB Research Center History

- **Founded in 1964**
- **Wholly-owned subsidiary of NAHB**
- **Independent, for-profit research firm**
- **Originally a small product testing lab**
- **Grown to full-service housing technology/product research firm**

NAHB Research Center Mission

**To improve the quality and
affordability of housing...**

Methodology

**Promote innovation in home
building products/systems,
technology, and construction
processes**

Capabilities

- **Market Research**
- **ISO 17025 accredited Test Lab**
- **Field Evaluations & Demonstrations**
- **Information Dissemination**
 - www.Toolbase.org
- **Green Building Certification**

Laboratory Credentials

*Recognized test laboratory, quality assurance agency,
and certified product listing agency*

- **IAS** (*International Accreditation Service*)
- **NIST – NVLAP** (*National Voluntary Laboratory Accreditation Program*)
- **U.S. Department of Housing & Urban Development Product Standards & Certification**
- **IAPMO** (*International Association of Plumbing and Mechanical Officials*)
- **City of Los Angeles, CA - Testing Agency License**

Lab & Market Research Facility

Completed Spring 2007



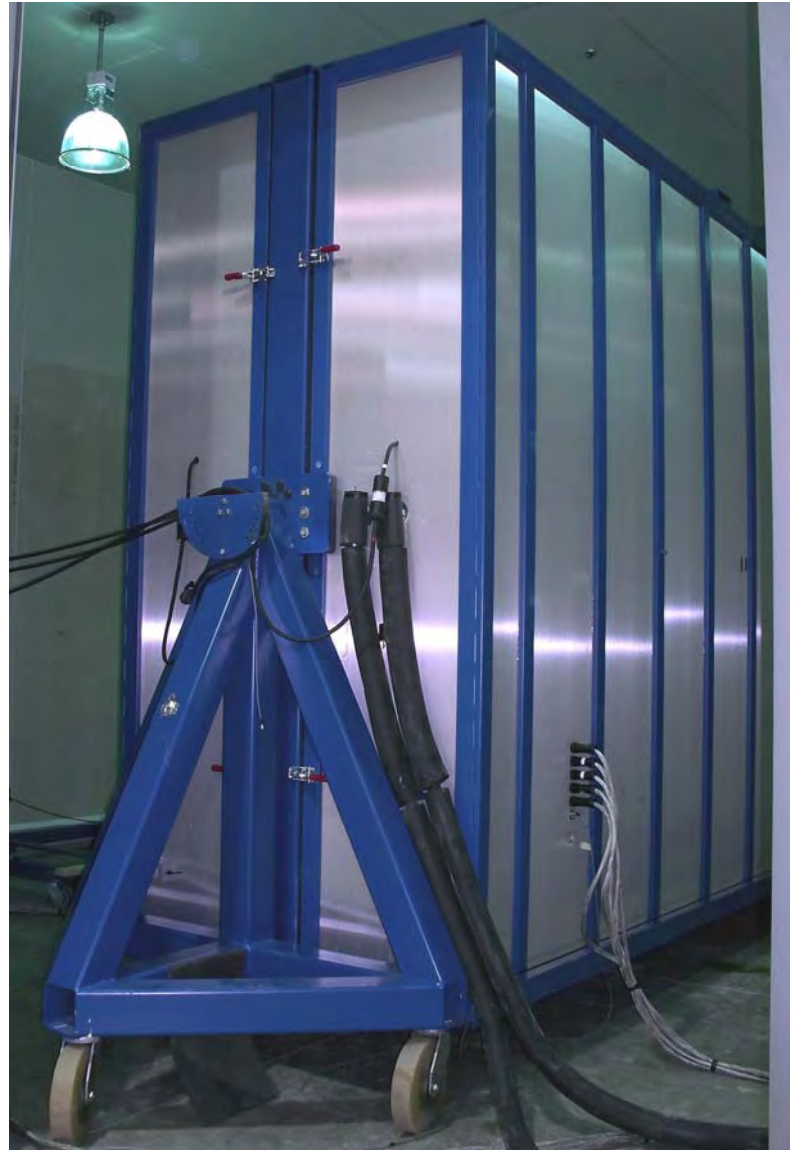
Shear Wall Structural Testing



Universal Test Machine



Calibrated Hot Box



The Changing Market

- **Energy Costs are rising rapidly**
- **80% of builders report energy efficiency impact their decisions**
- **Green building is gaining momentum**

Air Infiltration Opportunities

- **Windows/Doors**
- **Sill plates**
- **Band joists**
- **Penetrations**
- **Floors/Ceilings**
- **Walls**

Preventing Air Infiltration Options - Walls

- **Air Sealing Options**
 - **Caulk plates & seams**
 - **“picture fame” sealing**
- **House wrap**
- **Sealed sheathing systems**
- **Foaming**
- **Alternate technology (e.g. SIP, ICF)**

Test Wall

- 8' x 8'
- Vinyl Siding
- House wrap (optional w/ & w/o taped seams)
- OSB sheathing (7/16")
- 2 x 4 framing
 - 16" OC
 - Single bottom plate
 - Double top plate
- Various insulation materials
- 1/2 drywall
 - Screwed on
 - 1 coat of tape joint compound

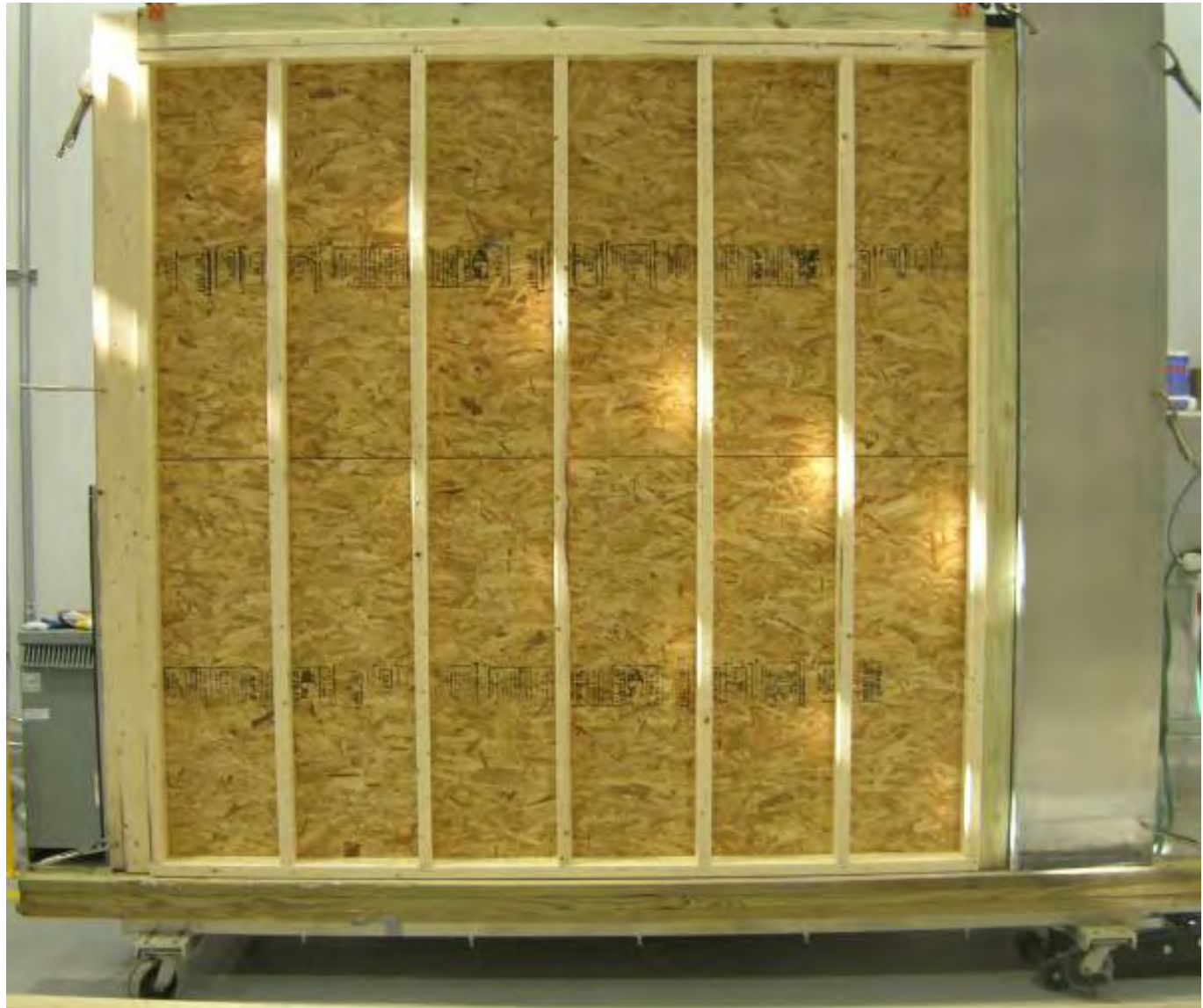
Test Wall

- **74 % of new homes use OSB or plywood sheathing**
- **73% use house wrap**
- **22% use vinyl siding**

TEST WALL

- **OSB installation**
 - **Horizontal**
 - **1/8” gap between sheets**
- **Penetrations**
 - **One interior electrical box/outlet w/ cover plate**
 - **One horizontal wiring run**

Test Wall



Test Wall House Wrap Details



1" cap nails

6" seam overlap

TEST WALL INSULATION

- **Insulation systems**
 - **Inset stapled kraft faced R-13 fiberglass batt**
 - **Face stapled kraft faced R-13 fiberglass batt**
 - **Net & blow loose fill fiberglass**
 - **Wet spray cellulose**
 - **1/2 pcf spray foam**
- **Contractor used for installation of net & blow, cellulose, and foam**

TEST Wall Installation

- **Top, bottom, & sides sealed to chamber with gasket & caulk**
- **Drywall sealing**
 - **Top & Sides caulked to framing**
 - Typically wall would extend and would be taped to ceiling
 - **Bottom not sealed**
 - Typically no additional sealing drywall to frame at base.

Test Plan

- **Test base wall w/o insulation**
- **Keep the “frame” constant**
- **Install insulation and/or house wrap & retest**
- **Modify system configuration & re-test**

Test Method

- **ASTM E283**
 - **Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen**

Test Method

- **Install test wall**
- **Cover/seal wall with plastic film**
- **Pressurize the chamber**
- **Measure flow to determine test chamber/system leakage**
- **Remove plastic film**
- **Pressurize chamber & measure leakage thru wall & chamber**
- **Subtract system leakage to get wall leakage**

- **Air flow from exterior to interior**

Test Method

- **Air flow measurement**
 - **Calibrated orifice plate**
 - **Inclined manometer**
 - **Two orifice plates available**
 - **Flow rate determined which plate to measure with**
 - **Each plate had a different uncertainty**

Test Plan - Wall 1

Test	House Wrap	Insulation
1-1	none	None
1-2	none	R-13 FG batt – inset stapled
1-2A	house wrap	R-13 FG batt – inset stapled
1-2B	house wrap – taped joints	R-13 FG batt – inset stapled
1-2C	house wrap – taped joints	R-13 FG batt – face stapled
1-3	house wrap – taped joints	R-15 blown in fiber glass
1-1A	house wrap – taped joints	None
1-4	none	R-13 damp spray cellulose
1-4A	house wrap	R-13 damp spray cellulose
1-4B	house wrap – taped joints	R-13 damp spray cellulose
1-2D*	house wrap – taped joints	R-13 FG batt – inset stapled
1-5	none	0.5 pcf spray foam
1-5A	house wrap	0.5 pcf spray foam
1-5B	house wrap – taped joints	0.5 pcf spray foam

* Vinyl siding added

Test Results - Wall 1 Fiberglass Insulation

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-1	no insulation no house wrap	6.2	12.3
1-2	inset FG batt no house wrap	3.6	7.2

% reduction with R-13 inset Fiberglass

42%

41%

Test Results - Wall 1 Fiberglass Insulation

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-2	inset FG batt no house wrap	3.6	7.2
1-2A	inset FG batt house wrap	0.86	1.8
1-2B	inset FG batt taped house wrap	0.37	0.35

% reduction by adding house wrap	76%	75%
% reduction with taping house wrap seams		
From no house wrap	90%	95%
From with house wrap	57%	80%

Test Results - Wall 1 Fiberglass Insulation Inset vs Face Stapling

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-2B	inset FG batt taped house wrap	0.37	0.35
1-2C	face FG stapled taped house wrap	0.26	0.4

% reduction with face stapling

30%

Test Results - Wall 1 Fiberglass Insulation Inset staple vs net & blow

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-2B	inset FG batt taped house wrap	0.37	0.35
1-3	blown in FG taped house wrap	0.04	0.1

% reduction with net & blow system

89%

71%

Test Results - Wall 1 Cellulose Insulation

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-1	no insulation no house wrap	6.2	12.3
1-4	cellulose no house wrap	1.29	2.7

% reduction with wet spray cellulose

79%

78%

Test Results - Wall 1 Spray Foam Insulation

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-1	no insulation no house wrap	6.2	12.3
1-5	spray foam no house wrap	0.00	0.1
1-5A	spray foam house wrap not taped	0.00	0.0
1-5B	spray foam taped house wrap	0.00	0.0

Testing Repeatability

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-2	inset FG batt no house wrap	3.6	7.9
1-2 (repeat)	inset FG batt no house wrap	3.6	6.4
	% difference	0	19%
1-2A	inset FG batt house wrap not taped	1.11	2.9
1-2A (repeat)	inset FG batt house wrap not taped	0.60	0.7
	% difference	46%	75%
1-2B	inset FG batt taped house wrap	0.40	0.4
1-2B (repeat)	inset FG batt taped house wrap	0.33	0.3
	% difference	18%	25%

House Wrap Effect

	Fiberglass (inset)		Cellulose	
	0.1''	0.3''	0.1''	0.3''
Reduction due to house wrap addition	76%	75%	68%	70%
Additional reduction with taped seams	57%	80%	80%	99%

House Wrap Effect

	No house Wrap		House Wrap		House Wrap Taped Seams	
	CFM @ 0.1''	CFM @ 0.3''	CFM @ 0.1''	CFM @ 0.3''	CFM @ 0.1''	CFM @ 0.3''
Inset Fiberglass	3.6	7.2	0.86	1.8	0.37	0.35
Face Stapled Fiberglass	--	--	--	--	0.47	0.5
Net & Blow Fiberglass	--	--	--	--	0.04	0.1
Cellulose	1.29	2.7	.41	0.8	0.08	0
Foam	0	0.1	0	0	0	0

Siding Effect

	House Wrap Taped Seams		House Wrap Taped Seams Vinyl Siding	
	0.1"	0.3"	0.1"	0.3"
Inset Fiberglass	0.37	0.35	0.47	0.57

Test Wall 2

- **Identical construction to wall 1**
- **EXCEPT**
 - **Wall installed on top of simulated band joist/joists/subfloor**
- **No sealing between bottom plate and subfloor**
- **Test chamber limited the depth of joist to 2x4**

Simulated floor system



Test Results

Wall 1 vs Wall 2

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-2	inset FG batt no house wrap	3.6	7.2
1-6	inset FG batt no house wrap w/ Band Joist	7.2	14.1

The band joist simulation doubled the air leakage

Test Results

Wall 1 vs Wall 2

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-2A	inset FG batt house wrap	0.86	1.8
1-6A	inset FG batt house wrap With Band Joist	2.06	3.7

The band joist simulation doubled the air leakage

Test Results

Wall 1 vs Wall 2

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-2B	inset FG batt taped house wrap	0.37	0.35
1-6B	inset FG batt taped house wrap w/ Band Joist	1.23	2.1

The band joist simulation more than tripled the air leakage

Test Results – Wall 2 over Band Joist

Test	Description (with band joist)	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-6	inset FG batt no house wrap	7.2	14.1
1-6A	inset FG batt house wrap not taped	2.06	3.7
1-6B	inset FG batt taped house wrap	1.23	2.1

Test Results – Wall 2 over Band Joist

% Reduction	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
By adding house wrap	71%	74%
After taping house wrap (reduction from no wrap)	83%	85%

Test Wall 3

- **Identical construction as Wall 1**
- **EXCEPT**
 - **Air sealed with caulk**
 - **Gap between OSB sheathing**
 - **“picture frame” inside of wall cavity**

Caulking Detail



Test Results

Wall 1 vs Wall 3

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-2	inset FG batt no house wrap	3.6	7.2
2-1	inset FG batt no house wrap caulked	0.83	1.2

Air Infiltration Reduction due to Caulking

77%

83%

Test Results

Wall 1 vs Wall 3

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-2B	inset FG batt taped house wrap	0.37	0.35
2-1A	inset FG batt taped house wrap caulked	0.16	0.01

Air Infiltration Reduction due to Caulking

57%

97%

Test Results

Wall 1 vs Wall 3

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-2C	face FG stapled taped house wrap	0.26	0.4
2-2A	face stapled FG batt taped house wrap caulked	0.16	0.1

Air Infiltration Reduction due to Caulking

38%

75%

Test Results

Wall 1 vs Wall 3

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
1-3	blown in FG taped house wrap	0.04	0.1
2-2C	blown in FG taped house wrap caulked	0.00	0.2

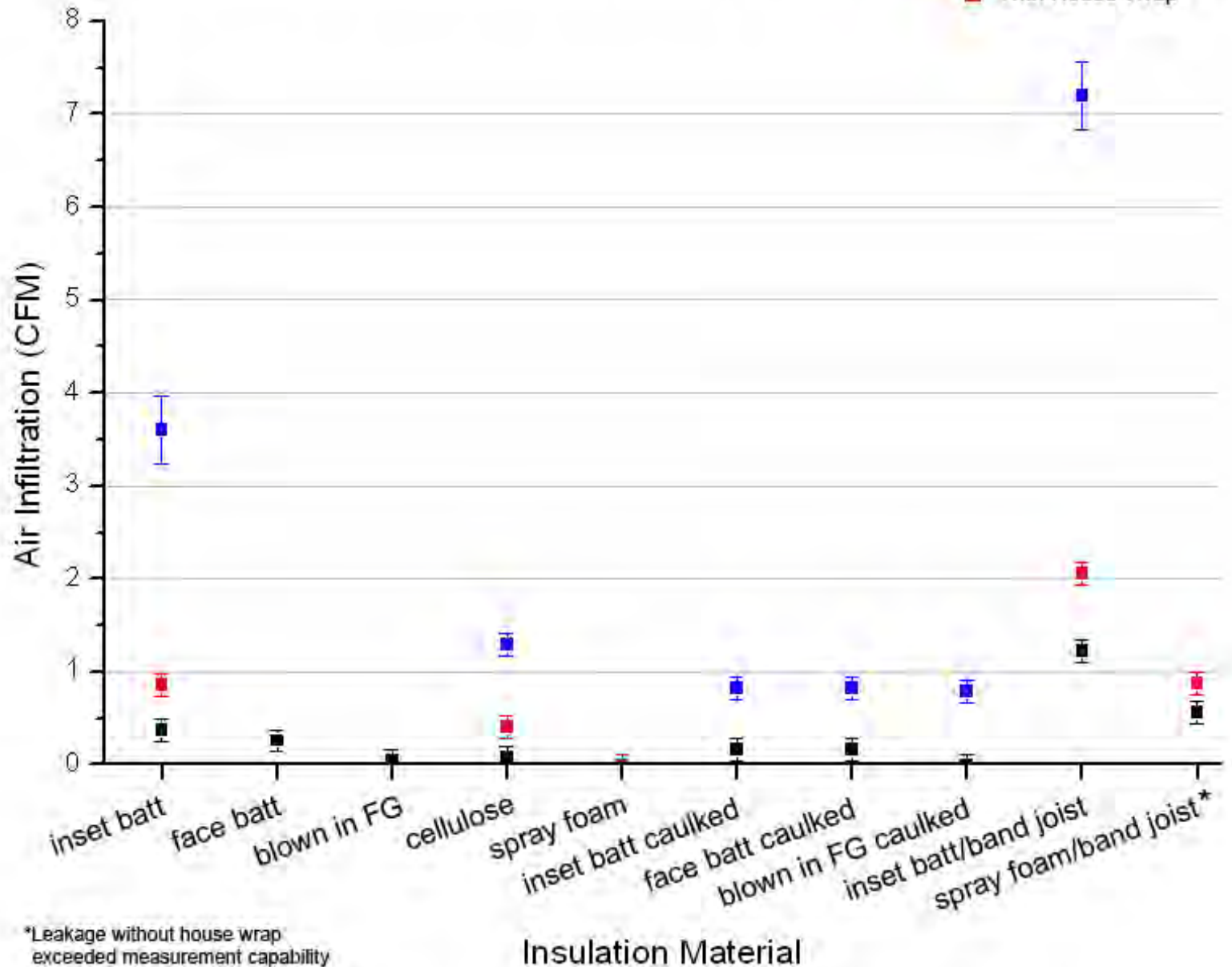
Test Results

Wall 4

Test	Description	CFM @ 0.1 W.C.	CFM @ 0.3 W.C.
2-3A	spray foam house wrap not taped w/ band Joist	0.87	1.3
2-3B	spray foam taped house wrap w/ band Joist	0.56	0.8

Air Infiltration with and without House Wrap at 0.1 in. H₂O

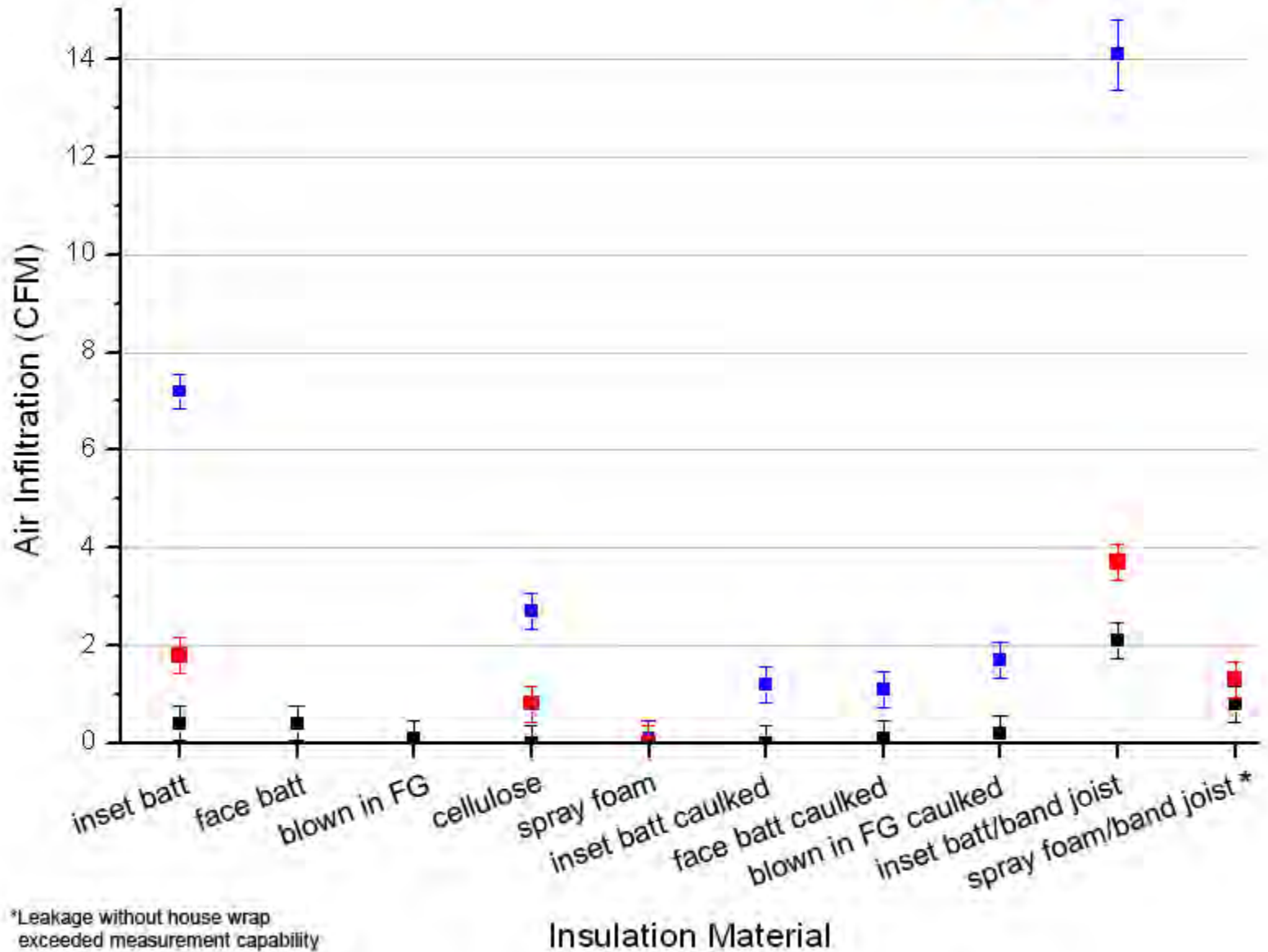
- With Taped House Wrap
- Without House Wrap
- With House Wrap



*Leakage without house wrap exceeded measurement capability

Air Infiltration with and without House Wrap at 0.3 in. H₂O

- With Taped House Wrap
- Without House Wrap
- With House Wrap



*Leakage without house wrap exceeded measurement capability

Test Wall 5

- **Similar to wall 1**
- **Except**
 - **Wall dimension 8.5' high x 10' long**
 - **Horizontal OSB**
 - **Two horizontal 1/8" gaps**

TEST WALL 5



Test Wall 6

- **Same as Wall 5**
- **Except**
 - **Vertical OSB**
 - **4' x 9' panels**
 - **Gapped 1/8" @ seams but all seams on framing**

Test Results

Test Wall	CFM At 0.1" H2O		CFM At 0.3" H2O	
	4 x 8 panels Wall 5	4 x 9 Panels Wall 6	4 x 8 panels Wall 5	4 x 9 Panels Wall 6
Base Wall	3.72	2.30	8.50	4.85
With House Wrap	2.49	1.76	3.86	3.03
With House Wrap Taped	0.48	0.21	1.24	0.46

Test Wall 7

- **Similar to Test Wall 1**
- **Except**
 - **8' high x 10' long**
 - **Vertical OSB (no horizontal gaps)**
 - **House wrap – no tape**
 - **Vinyl Siding**
 - **Net & blow fiberglass insulation**

Test Results - Wall 7

Density Effect

Fiberglass

Density pcf	CFM @ 0.2"	CFM @ 0.3"
1.85 (typical)	1.65	2.25
2.46 (dense pack)	1.27	1.51

Reduction due to dense packing

23%

33%

Test Results - Wall 7

Density Effect

Cellulose

Density pcf	CFM @ 0.2"	CFM @ 0.3"
3.00 (typical)	1.60	2.04
3.74 (dense pack)	1.30	1.64

Reduction due to dense packing

19%

20%

Test Results - Wall 7 Spray Foam

CFM @ 0.2"	CFM @ 0.3"
1.39	2.53

Conclusions

- **For clear walls with fiberglass or cellulose insulation**
 - **House wrap provides a significant reduction in air infiltration (~75%)**
 - **Taping house wrap seams provides another significant reduction (~50-90%)**

Conclusions

- **For clear walls with band joist and with fiberglass or cellulose insulation**
 - **House wrap provides a significant reduction in air infiltration (~70-75%)**
 - **Taping house wrap seams provides another significant reduction (~40-45%)**

Conclusions

- **For tall clear walls eliminating horizontal gaps reduces air infiltration 25-60%**
- **Dense packing blown in systems reduces air infiltration by 20-30%**

Conclusions

- **Details are important**
- **Remember**
 - **Clear walls are not the only source of air infiltration**

- **Thanks to**

- **NAIMA**
- **Norbord**
- **Owens Corning**

For allowing the use of their data



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