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Commonwealth of Massachusetts
Division of Professional Licensure
Office of Public Safety and Inspections

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COMMISSIONER, DIVISION OF PROFESSIONAL LICENSURE

BOARD OF BUILDING REGULATIONS AND STANDARDS

NOTICE OF MEETING

In accordance with the provisions of G.L. c. 30A § 20, notice is hereby given that the Board of Building Regulations and Standards (BBRS) will convene a regular monthly meeting and statutory public hearing on:

November 14, 2018 @ 10:00 a.m. until approximately noontime @
The Boston Society of Architects Office
290 Congress Street in Boston.

Posted on November 6, 2018

It is anticipated that the topics shown below will be discussed at the aforementioned meeting:

AGENDA

Roll Call, by BBRS Chair:

John Couture, Chair	☐ present ☐ absent	Robert Anderson, or designee	☐ present ☐ absent
Kerry Dietz, Vice Chair	☐ present ☐ absent	Peter Ostroskey, or designee	☐ present ☐ absent
Richard Crowley, Second Vice Chair	☐ present ☐ absent	Michael McDowell	☐ present ☐ absent
Steve Frederickson	☐ present ☐ absent	Susan Gleason	☐ present ☐ absent
Kevin Gallagher	☐ present ☐ absent	Lisa Davey	☐ present ☐ absent
Cheryl Lavalley	☐ present ☐ absent		

Public Hearing Proposals

Change Proposals Relating to Energy Code Requirements

Code change proposal are attached to this agenda in the order in which they appear below.

- **Proposal Number 11-1-2018** – Consider revising Sections R401.2 and R407.
  Proponent: Kevin Rose, ***Mass Save***

- **Proposal Number 11-2-2018** – Consider revising Section r402.4.
  Proponent: Kevin Rose, ***Mass Save***

- **Proposal Number 11-3-2018** – Consider revising Sections R806.5, and 1203.1.2.3.
  Proponent: Christopher Alphen, ***Dolphin Insulation***

- **Proposal Number 11-4-2018** – Consider revising Sections C401.2, C403.7 and C403.8.
  Proponent: Brenden Giza-Sisson, ***Mass Save***

- **Proposal Number 11-5-2018** – Consider revising Sections C401.2 and C405.2.3.
  Proponent: Brenden Giza-Sisson, ***Mass Save***

- **Proposal Number 11-6-2018** – Consider revising Sections C401.2, C405.4 and C406.3.
  Proponent: Brenden Giza-Sisson, ***Mass Save***

- **Proposal Number 11-7-2018** – Consider revising Section C405.
- **Proponent:** Brenden Giza-Sisson, ***Mass Save***

- **Proposal Number 11-8-2018** – Consider revising Section C405.3.2.
  Proponent: Brenden Giza-Sisson, ***Mass Save***

- **Proposal Number 11-9-2018** – Consider revising Section C405.2.2.1.
  Proponent: Glenn Heinmiller, ***International Association of Lighting Designers***

- **Proposal Number 11-10-2018** – Consider revising Section C406.4.
  Proponent: Glenn Heinmiller, ***International Association of Lighting Designers***

- **Proposal Number 11-11-2018** – Consider revising Section C503.1.
  Proponent: Glenn Heinmiller, ***International Association of Lighting Designers***

Change Proposals Relating to Swimming Pool Code Requirements

- **Proposal Number 11-12-2018** – Consider revising Section 305 of the ***International Swimming Pool & Spa Code*** (ISPSC).
  Proponent: Tom Moberg, Town of Acton

Change Proposals Relating to Residential Code Requirements Large Additions

- **Proposal Number 11-13-2018** – Consider Sections R313.2, AJ102.3 and add AJ102.3.2.
  Proponent: Fire Prevention\Fire Protection (FPFP) Committee

Editorial Change Proposals Relating to Varied Code Sections

These changes have identified by code users as requiring correction.

- **Proposal Number 11-14-2018** – Consider correcting Sections 305.2 and 308.6.1 having to do with day care age requirements.
  Proponent: OPSI Building Inspectors Gordon Bailey & David Holmes

- **Proposal Number 11-15-2018** – Consider correcting Sections AF103.4.2 and 103.4.3 having to do with radon control requirements.
  Proponent: Mike Grover, City of Cambridge

- **Proposal Number 11-16-2018** – Discuss meaning of Section 501.1 Note 3 pertaining to construction requirements for hospitals and nursing homes.
  Proponent: Mark Hughes, Town of Framingham

Regular Meeting

1. **Review\Vote** approval of October 9, 2018 BBRS draft meeting minutes.
2. **Review\Vote** approval of September 19, 2018 BOCC draft meeting minutes.
3. **Discuss** locking arrangements and associated hardware installed to protect against active shooter or other threatening situations in a building\structure.
4. **Discuss** progress relating to the next edition of 780 CMR.
5. **Discuss Code Change Proposal Number 5-7-2018** – Regarding developing a swimming pool installers license\certification based on the ***Association of Pool & Spa Professionals*** (APSP) standards.
6. **Discuss** Advisory Committee make-up.
   a.) Cannabis
   b.) Geotechnical
   c.) Fire Prevention\Fire Protection (FPFP)
   d.) Others
7. **Discuss** progress of Manufactured Buildings Study Group.
8. **Discuss** approval of 135 new CSLs issued in the month of September, 2018.
9. **Discuss\Vote**
   CSL Average Passing Score\Medical\Military\Age or Continuing Education Requirements.
   a.) xxx
10. **Discuss** 2019 meeting dates.
11. **Discuss** BCAB and full Board Training.
12. **Discuss** other matters not reasonably anticipated 48 hours in advance of meeting.

11-1-2018

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MASSACHUSETTS STATE BUILDING CODE – CODE AMENDMENT FORM

Impacted code:	☐ 10th Edition Base Code ☒ 10th Edition Residential Code	State Use Only	
Date Submitted:	**10/12/18**	Date Received:	
Code Section:	**R 401.2, R407**	Code Change Number:	11-1-2018
Name of proponent:	**Kevin Rose**		
Company / Organization represented, if any:	**Mass Save** Check ☐ if representing self		
Address (number, street, city, state, ZIP):	**Mass Save is a collaborative of Massachusetts' natural gas and electric utilities and energy efficiency service providers, including Berkshire Gas, Blackstone Gas Company, Cape Light Compact, Columbia Gas of Massachusetts, Eversource, Liberty Utilities, National Grid and Unitil.**		
Telephone number:	**781.907.3595**		
Email address:	**Kevin.Rose@nationalgrid.com**		

PLEASE CHECK OFF THE TYPE OF AMENDMENT PROPOSED

☒ Change existing section language ☒ Add new section ☐ Delete existing section and substitute
☐ Delete existing section, no substitute ☐ Other, Explain: ______________________

PLEASE TYPE THE PROPOSED AMENDMENT BELOW. If you propose to change a section, please copy the original text from either the relevant model code and/or MA amendment. Indicate, with a strikethrough, the text that you propose to delete. Please also indicate any new text in both *italic* and red font. Finally, for each proposal submitted, please provide the justification items requested below. Completed code amendment forms may be emailed to Felix Zemel, Director of Code Development and Manufactured Buildings at felix.zemel@state.ma.us. Please attach additional pages as necessary.

Existing language and Proposed changes:

1) Amend section R401.2 as follows:

R401.2 Compliance
Projects shall comply with the following:
1. Sections R401 through R404 *and R407*.
2. Section R405 and the provisions of Sections R401 through R404 indicated as "Mandatory"
3. The energy rating index (ERI) approach in Section R406.

2) Add new section R407 as follows:

R407 Additional Efficiency Packages

R407.1 Requirements (Prescriptive)
Projects shall comply with at least one of the following:
1. *More efficient HVAC performance in accordance with Section R407.2*
2. *Heat recovery ventilation (HRV) system in accordance with Section R403.6.1. The Exception in R403.6.1 shall not be applied if used for compliance with this Section.*
3. *High efficiency water heater or solar thermal hot water heater in accordance with Section R407.3*

R407.2 More efficient HVAC performance. *Heating and cooling equipment shall meet at least one of the following efficiency requirements:*
1. *Gas, propane or oil-fired furnaces shall have a minimum AFUE of 95%*
2. *Gas, propane or oil-fired boilers shall have a minimum AFUE of 95%*
3. *Closed-loop ground source heat pump with a minimum COP of 3.5.*

R407.3 High efficiency water heating or solar thermal hot water heater. *Hot water heating systems shall meet one of the following:*
1. *Natural gas or propane water heating with a minimum Uniform Energy Factor (UEF) of 0.87 or electric heat pump hot water heater with a minimum UEF of 2.2 in accordance with DOE 10 CFR Part 430, Subpart B, Appendix E. On-demand natural gas or propane water heaters shall not include any buffer tank or hot water storage capacity outside the water heater itself.*
2. *A solar thermal hot water heating system with a minimum of 40 square feet of gross collection area. The solar hot water heating panels shall have a total solar resource fraction that is not less than 75%.*

3) Add new Referenced Standard to Chapter 6 [RE] as follows:

DOE

U.S. Department of Energy
1000 Independence Ave SW
Washington, DC 20585

10 CFR Part 430, Subpart B, Appendix E: Uniform Test Method for Measuring the Energy Consumption of Water Heaters

R407.3

Background and rationale: This proposal seeks to secure a nontrivial increase in efficiency for homes built to the new state energy code compared to the current code while providing builders with flexibility in how to achieve this added efficiency. The proposal promotes more efficient heating and water heating equipment without violating federal equipment preemption laws associated with the miniumum efficiency levels provided by NAECA. This is achieved by making these improvements optional and including a third option that requires mechanical ventilation be delivered by an HRV. Making HRV optional serves to promote balanced ventilation – an integral strategy for the ultra-low energy use homes – without mandating it. The "choose one of three options" structure of this section intentionally mirrors the first version of Section C406 of the commercial code.

The efficiency levels proposed are derived from a rigorous, third party study from 2016 of 146 new homes built in Massachusetts. Below is justification information for both the heating and water heating options.

- Heating: Tables 51, 52, 53, and 54 show that the median AFUE of gas and propane furnaces and boilers installed in Massachusetts is consistently 95-96% regardless of the code the home was built to (whereas the three oil furnaces and boilers in this sample had an AFUE of 83-85%). Table 57 whoes that there was only one ground source heat pump included in the sample, and it had a COP of 4.0. As such the target COP was reduced to 3.5 to avoid being too aggressive.
- Water heating: Table 73 shows the average and median Energy Factor for all fossil fuel indirect water heaters was 0.87. Instantaneous solutions deliver higher Energy Factors than 0.87 for almost all of the 43 products in the sample. And, for 16 heat pump water heaters in the sample, the median Energy Factor was 2.45. As with the the ground source heat pump efficiency level below, we have reduced the efficiency target for heat pump water heaters to 2.2, which was selected to ensure alignment with Energy Star product certification requirements across all productsizes and capacities. Notably, we have proposed using the "new" Uniform Energy Factor (UEF) as the metric for water heaters and have provided a supporting reference standard.

The basis of this requirement and the source of the solar thermal requirement is the 2016 Stretch Code Supplement to the 2016 New York State Energy Conservation Construction Code. Development of this resource was led by New Buildings Institute.

Pros of the proposed change: First, it reduces electricity and/or gas cost for owners/occupants of new homes. Second, it better aligns stringency of Prescriptive path with HERS path (R406) while providing builders with flexibility for achieving this added efficiency. Third, it mirrors Section C406 to simplify ease of use of the code for code officials, builders, designers, subcontractors, and others who work on both residential and commercial projects.

Cons of the proposed change: Increases first cost for home builder.

Estimated impact on life safety: Choosing either the *More efficient HVAC performance* or the *High efficiency water heating or solar thermal hot water heater* options would, by nature of the efficiency levels set, require either sealed combustion or technologies that do not require combustion. All such solutions significantly or completely reduce the life safety risks associated with backdrafting of combustion byproducts into the living space. Chooseing the HRV option, on the other hand, replaces the typical incumbent exhaust-only strategy for mechanical ventilation with a balanced ventilation system. Balanced ventilation has the benefit of improving the quality of the air supplied to a home by drawing the air directly from outside (as opposed to drawing it in a much less controlled manner through cracks and gaps in wall cavities as in exhaust-only approaches).

Estimated impact on cost: Incremental cost for this measure is difficult to measure due to the wide array of compliance options available.

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Memo: VAV Lab Exhaust Controls

Expedited Services: Applicability of CA Title 24 2019 CASE Report Results to MA Market
Date: September 23, 2018
Client Contact: Brendan Giza-Sisson, david.giza-sisson@eversource.com

Summary

The goal of this Expedited Services assignment was to assess the reasonability of the energy savings estimates in the CASE report for the 2019 version of California Title 24 on variable speed lab exhaust fan control, and the applicability of these estimates to the Massachusetts lab market. We also address some specific questions posed by Eversource.

We find that most of the CASE study carries across to the Massachusetts market with little modification. We recommend that a suitable formulation of the 2019 Title 24 lab exhaust efficiency requirements be investigated as a supplement to the requirements of ASHRAE 90.1.

While we have some concerns relating to the detailed CASE savings calculations, we believe that these potential issues have led to conservative savings estimates. As a cross-check on overall savings, we developed a separate analysis for wind-responsive induction exhaust fan systems in the Boston area. Our results of ~3 kWh/yr/sf of lab space are in line with the CASE report results for California. A control scheme responsive to exhaust stream chemical concentration would likely lead to similar or greater savings.

The design of all types of exhaust stacks is typically very conservative. While it was not included in 2019 Title 24, a requirement for wind-responsive controls for traditional exhaust stacks could provide significant additional energy savings.

Additional Details

Brief summary of results:

For induction exhaust fan systems, which cannot easily meet the new Title 24 prescriptive upper limit on exhaust fan power at design conditions, the CASE report predicted savings of ~4-5 kWh/yr/sf of lab space due to wind-responsive VAV operation. For traditional (non-induction) exhaust stack systems, the report predicted savings of ~1 kWh/yr/sf of lab space due to the lower power requirements of new systems designed to meet the maximum fan power allowance.

Information reviewed:

1) Codes and Standards Enhancement (CASE) Initiative: Variable Exhaust Flow Control – Final Report, August 2017
2) ASHRAE 90.1-2013
3) CA Title 24 Part 6, 2016
4) Discussions with CASE report author over email
5) Discussion with CPP Wind staff via phone call.

General validity of CASE report assumptions and methodology:

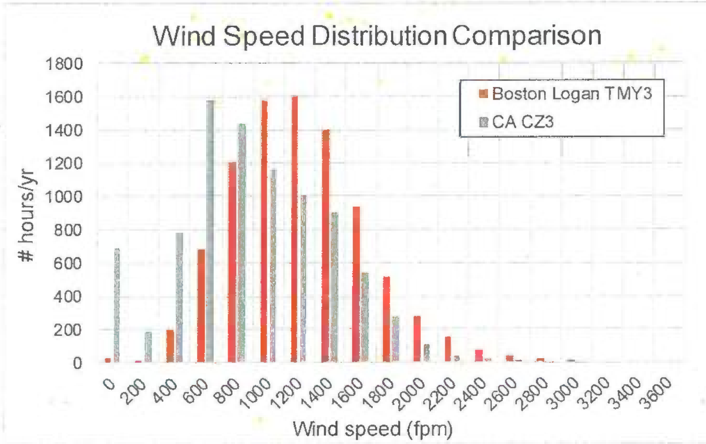
The report used a set of spreadsheet calculations based on several assumptions about exhaust fan system design and lab building design and operations. While kW Engineering did not have access to the calculation details or fan selections in baseline or proposed cases, the general assumptions appear reasonable. However, some potential issues were identified:

1) Lab sizes taken from the Center for Energy Efficient Labs (CEEL) Market Assessment (ETCC) report: the CASE study interpreted these lab sizes as corresponding to total lab areas within buildings. However, the areas given in the CEEL report represented individual lab suites within buildings. The new Title 24 requirement for wind-responsive systems does not apply to exhaust systems less than 10,000 cfm in size (corresponding to lab areas less than around 5,000-10,000 sf). All else being equal, systems with lower exhaust airflow experience lower plume rise; therefore, savings projections derived from these systems would be conservative.
2) Highly variable savings projections between California climate zones: There is no clear reason for the factor of >50-times difference between the savings projections for CZ2 (highest) and CZ14 (lowest) savings projection. The author of the report (via email conversations) did not provide an explanation for this difference, leading to concerns that some of the savings calculations could include potential issues. It appears likely that these issues would have made the savings projections more conservative.

Differences between existing MA and CA code requirements:

1) Apparent lack of applicability of Title 24 to lab occupancy: despite the name, the "L" occupancy classification, to which the CASE report states that Title 24 does not apply, is not the classification assigned to the majority of lab space in California. The majority of lab space is classified as B occupancy; typically only labs with high chemical storage requirements receive L classifications. This apparent difference between California and Massachusetts is not significant.
2) Absence of current fan power limitations for lab exhaust in Title 24: ASHRAE 90.1 includes explicit (prescriptive) fan power allowances for lab exhaust systems. Reducing these allowances might result in exhaust fan power savings for new systems; however, these savings could be accommodated in other aspects of the ventilation system design (which may already operate at variable fan speed, reducing the annual energy impact of any design changes). On a per-unit-area basis, the CASE savings associated with variable exhaust fan speed operation (for induction systems) significantly exceed those associated with the introduction of simple fan power allowances. Regardless of the existing code allowance for lab exhaust systems in ASHRAE 90.1, any wind-responsive variable speed exhaust fan operation is expected to result in significant percentage savings for exhaust fan systems of any type (except for very tall traditional stacks for which the design stack velocity is close to zero).

3) Differing wind patterns between MA and CA: on average, Massachusetts is windier than California. However, because exhaust fan systems are typically designed in a conservative manner (such that a large fraction of hours of the year do not require design stack velocity), it is not expected that this difference will result in significantly lower savings for the Boston area.



Location	ASHRAE 1% design wind speed	Average wind speed	% of hours with wind speed < 60% of 1% speed
CA CZ3 (Oakland)	23.6 mph = 2080 fpm	780 fpm	78%
Boston Logan TMY3	26.0 mph = 2290 fpm	1070 fpm	77%

Approximate Savings Calculation

We developed rough savings estimate for wind-responsive lab exhaust fan control (versus a baseline of constant exhaust fan speed operation with bypass) for Boston; see the table below. It is assumed that the majority of lab space in Massachusetts is in the greater Boston area. We performed this calculation as a cross-check on the CASE results; the calculation is designed to be conservative.

System Properties			
Induction exhaust fan bhp	0.0013	bhp/cfm	From fig 3 of CASE report; typical for 4" TSP at design conditions
Induction exhaust fan power	1.1	W/cfm	Assuming 90% motor efficiency
Typical lab ventilation rate	1.0	cfm/sf	Also used for lab exhaust rate during normal occupied hours
Exhaust fan power intensity	1.1	W/sf	of lab space (multiplying the two rows above)
Base case			
Exhaust fan power (all times)	1.1	W/sf	Bypass damper operates to keep stack velocity constant
Annual exhaust fan usage	9.4	kWh/sf	
Proposed case			
Occupied mode exhaust fan power	1.1	W/sf	No credit taken for design using dispersion study or off-design flow
Occupied hours/yr	2000	hours/yr	8h/weekday, same as CASE report
Unocc ventilation rate	0.6	cfm/sf	Assuming 40% flow reduction (typical for newer lab buildings)
Unocc exhaust fan power	0.30	W/sf	When permitted by wind conditions; power law index of 2.5 (very approx)
Unocc hours/yr	6760	hours/yr	
Fraction of low wind speed hours	77%	of hours	when wind speed is less than 60% of 1% design speed (for Boston)
Fraction of buildings with high neighbors	20%	of bldgs	Cases where stack velocity reduction is not permitted
Hours with reduced stack velocity	4164	hours/yr	From above three rows
Annual exhaust fan usage	6.2	kWh/yr/sf	
Energy Savings			
Annual exhaust fan savings	**3.2**	**kWh/yr/sf**	

Notes on assumptions/inputs:

- Savings estimate for wind-responsive systems only
- No savings credit taken for reduced velocity pressure due to operating at stack velocity below 3000 fpm at design conditions (which may often be enabled by incorporation of a wind dispersion analysis in system design).
- Wind direction effects not considered; % of hours with lower permitted stack velocity would be expected to be higher if direction were taken into account.
- Higher urban density correction: in greater Boston, more than in most of California, labs are frequently concentrated in urban areas with many tall buildings. Stack design and exit velocity requirements are typically more stringent when tall buildings are nearby. For this reason, a 20% reduction in the overall savings potential was applied. Note also that induction stack systems are likely to be found more commonly in urban areas.

Note on Results

The results of our rough analysis are in line with those of the CASE study. We recommend using 3 kWh/yr/sf of lab space as a conservative estimate of the savings potential of implementing wind-responsive exhaust fan system controls for labs in Massachusetts with induction exhaust fan systems. We further recommend a more detailed study of lab exhaust fan types, sizes, and typical design parameters for Massachusetts as part of the more precise savings projections required before code requirements are finalized.

11-2-2018

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MASSACHUSETTS STATE BUILDING CODE – CODE AMENDMENT FORM

Impacted code:	☐ 10th Edition Base Code ☒ 10th Edition Residential Code	State Use Only	
Date Submitted:	**10/12/18**	Date Received:	
Code Section:	**R402.4**	Code Change Number:	11-2-2018
Name of proponent:	**Kevin Rose**		
Company / Organization represented, if any:	**Mass Save** Check ☐ if representing self		
Address (number, street, city, state, ZIP):	**Mass Save is a collaborative of Massachusetts' natural gas and electric utilities and energy efficiency service providers, including Berkshire Gas, Blackstone Gas Company, Cape Light Compact, Columbia Gas of Massachusetts, Eversource, Liberty Utilities, National Grid and Unitil.**		
Telephone number:	**781.907.3595**		
Email address:	**Kevin.Rose@nationalgrid.com**		

PLEASE CHECK OFF THE TYPE OF AMENDMENT PROPOSED

☒ Change existing section language ☐ Add new section ☐ Delete existing section and substitute
☐ Delete existing section, no substitute ☐ Other, Explain: ______________________

PLEASE TYPE THE PROPOSED AMENDMENT BELOW. If you propose to change a section, please copy the original text from either the relevant model code and/or MA amendment. Indicate, with a strikethrough, the text that you propose to delete. Please also indicate any new text in both *italic* and red font. Finally, for each proposal submitted, please provide the justification items requested below. Completed code amendment forms may be emailed to Felix Zemel, Director of Code Development and Manufactured Buildings at felix.zemel@state.ma.us. Please attach additional pages as necessary.

Existing language and Proposed changes:

Amend Table R402.4.1.1 as follows:

TABLE R402.4.1.1
AIR BARRIER AND INSULATION INSTALLATION

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
General requirements	A continuous air barrier shall be installed in the building envelope. The exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed.	*All insulation shall be installed at Grade I quality in accordance with ICC/RESNET 301.* Air-permeable insulation shall not be used as a sealing material.

(remainder of table is unchanged)

Background and rationale: New construction is the only opportunity to properly install insulation throughout a home in a cost-effective manner. Furthermore, poor installation is a wasteful construction practice as it wastes the benefits promised by insulation products by greatly reduce their effectiveness in reducing heat transfer.

A 2016 study of 146 new homes in Massachusetts shows that insulation installation in the state has significant room for improvement. Table 14 of this study provides the full breakdown of insulation installation quality data in these 146 homes; the primary finding is that the vast majority of homes in the state receive merely fair installation quality.

> "Auditors estimated that 86% of homes have mostly Grade II, a typical installation quality represented by moderate amounts of gaps and compression. Grade I—the best quality, representing an install with limited installation defects—is the majority install quality in only 10% of the homes." (pg. 17)

Currently, the code requires that insulation is installed "in accordance with the manufacturer's instructions." As these instructions varies by product and manufacturer, the code requirement for insulation installation quality may not be well understood across the industry and is difficult to enforce.

The intent of this code change is establish a single, consistent standard for high quality insulation installation by leveraging ICC/RESNET 301, a consensus standard already referenced by the 2018 IECC. Note that this requirement would not require a HERS Rater to verify the insulation installation quality but does promote the ability of HERS Raters to support improved code compliance and energy savings.

Pros of the proposed change: Decreased energy costs for home owners and occupants. Increased enforceability of insulation installation quality for code officials.

Cons of the proposed change: Potentially increased time spent on installation by insulation contractors.

Estimated impact on life safety: No significant impact.

Estimated impact on cost: None- this proposal does not require a HERS Rater or other hired professional to verify the insulation installation quality.

11-3-2018

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MASSACHUSETTS STATE BUILDING CODE – CODE AMENDMENT FORM

Impacted code:	☐ 9th Edition Base Code ☐ 9th Edition Residential Code	State Use Only	
Date Submitted:		Date Received:	
Code Section:	**R806.5 780 CMR 1203.1.2.3**	Code Change Number:	11-3-2018
Name of proponent:	**Christopher Alphen**		
Company / Organization represented, if any:	Dolphin Insulation Inc. Check ☐ if representing self		
Address (number, street, city, state, ZIP:	**410 Great Road A6 – Littleton MA 01460**		
Telephone number:	**978-266-1122**		
Email address:	**chris@dolphin-insulation.com**		

PLEASE CHECK OFF THE TYPE OF AMENDMENT PROPOSED

☐ Change existing section language ☐ Add new section ☐ Delete existing section and substitute
☐ Delete existing section, no substitute ☐ Other, Explain: ______________________________

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Existing language:

R806.5 Unvented roof assemblies

5. Insulation shall be located in accordance with the following:

5.1. Item 5.1.1, 5.1.2, 5.1.3 or 5.1.4 shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.

5.1.1. Where **only air-impermeable insulation is** provided, it shall be applied in direct contact with the underside of the structural roof sheathing.

5.1.2. Where air-permeable insulation is provided inside the building thermal envelope, it shall be installed in accordance with Section 5.1.1. In addition to the *air-permeable insulation* installed directly below the structural sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing in accordance with the *R*-values in Table R806.5 for condensation control.

5.1.3. Where both air-impermeable and air-permeable insulation are provided, the air-impermeable insulation shall be applied in direct contact with the underside of the structural roof sheathing in accordance with Item 5.1.1 and shall be in accordance with the *R*-values in Table R806.5 for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.

5.1.4. Alternatively, sufficient rigid board or sheet insulation shall be installed directly above the structural roof sheathing to maintain the monthly average temperature of the underside of the structural roof sheathing above 45°F (7°C). For calculation purposes, an interior air temperature of 68°F (20°C) is assumed and the exterior air temperature is assumed to be the monthly average outside air temperature of the three coldest months.

5.2. Where preformed insulation board is used as the air-impermeable insulation layer, it shall be sealed at the perimeter of each individual sheet interior surface to form a continuous layer.

Exceptions:

Proposed changes:
To be added to existing language under number 5.1.2

- ***5.1.2.1 Air permeable insulation and smart vapor retarder is used on the conditioned side of the insulation and shall conform to all of the following requirements:***
  - ***5.1.2.1.1 Air permeable insulation is placed directly contact with the underside of the m minimum of 66% of total roof R-value***
  - ***5.1.2.1.2 Dense packed air permeable insulation is installed at manufacturer's recommended density***
  - ***5.1.2.1.3 Air permable batt insulation is installed as class I grade insulation and inspected by AHJ before being covered by smart vapor retarder***
  - ***5.1.2.1.4 Smart vapor retarder has an air permeability of maximum 0.02L/s-m2 per ASTM E2178 and as part of Air barrier system tested has a maximum air permeability of 0.2L/s-m2 per ASTM E2357***
  - ***5.1.2.1.5 Vapor permeance of smart vapor retarder per ASTM E96:***
    - ***5.1.2.1.5.1 Dry cup, below 0.25 perms***
    - ***5.1.2.1.5.2 Wet cup, above 5 perms***

Background and rationale:

5.1.2. Where air-permeable insulation is provided inside the building thermal envelope, it shall be installed in accordance with Section 5.1.1. In addition to the *air-permeable insulation* installed directly below the structural sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing in accordance with the *R*-values in Table R806.5 for condensation control.

5.1.3. Where both air-impermeable and air-permeable insulation are provided, the air-impermeable insulation shall be applied in direct contact with the underside of the structural roof sheathing in accordance with Item 5.1.1 and shall be in accordance with the *R*-values in Table R806.5 for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.

5.1.4. Alternatively, sufficient rigid board or sheet insulation shall be installed directly above the structural roof sheathing to maintain the monthly average temperature of the underside of the structural roof sheathing above 45°F (7°C). For calculation purposes, an interior air temperature of 68°F (20°C) is assumed and the exterior air temperature is assumed to be the monthly average outside air temperature of the three coldest months.

5.2. Where preformed insulation board is used as the air-impermeable insulation layer, it shall be sealed at the perimeter of each individual sheet interior surface to form a continuous layer.

Exceptions:

Proposed changes:
To be added to existing language under number 5.1.2

- **5.1.2.1 Air permeable insulation and smart vapor retarder is used on the conditioned side of the insulation and shall conform to all of the following requirements:**
  - **5.1.2.1.1 Air permeable insulation is placed directly contact with the underside of the roof deck and with the smart vapor retarder providing an interior airbarrier to a minimum of 66% of total roof R-value**
  - **5.1.2.1.2 Dense packed air permeable insulation is installed at manufacturer's recommended density**
  - **5.1.2.1.3 Air permable batt insulation is installed as class I grade insulation and inspected by AHJ before being covered by smart vapor retarder**
  - **5.1.2.1.4 Smart vapor retarder has an air permeability of maximum 0.02L/s-m2 per ASTM E2178 and as part of Air barrier system tested has a maximum air permeability of 0.2L/s-m2 per ASTM E2357**
  - **5.1.2.1.5 Vapor permeance of smart vapor retarder per ASTM E96:**
    - **5.1.2.1.5.1 Dry cup, below 0.25 perms**
    - **5.1.2.1.5.2 Wet cup, above 5 perms**

Background and rationale:
The background and rationale of this assembly is to eliminate the application and requirement of closed cell foam on the underside of the sheathing.

Pros of the proposed change:
The proposed change meets all of the moisture management standards and requirements and has no significant combustible potential nor does it have any significant off gassing potential

Cons of the proposed change:
There are None

Estimated impact on life safety:
Significant positive impact on life safety are achieved. Examples being a significant reduction of highly combustible material and also a significant reduction in off gassing and dangerous smoke development

Estimated impact on cost:
The elimination of several inches of closed cell foam has a significant impact on cost reduction in non-vented roof assemblies.

Background and rationale:
The background and rationale of this assembly is to eliminate the application and requirement of closed cell foam on the underside of the sheathing.

Pros of the proposed change:
The proposed change meets all of the moisture management standards and requirements and has no significant combustible potential nor does it have any significant off gassing potential

Cons of the proposed change:
There are None

Estimated impact on life safety:
Significant positive impact on life safety are achieved. Examples being a significant reduction of highly combustible material and also a significant reduction in off gassing and dangerous smoke development

Estimated impact on cost:
The elimination of several inches of closed cell foam has a significant impact on cost reduction in non-vented roof assemblies.

September 10, 2018

Dear Sirs/Madam

Dolphin Insulation is a family-owned and operated insulation company based in Littleton, MA. Our company has been serving homeowners of the greater Boston area since 2003. At Dolphin we have changed the traditional approach to insulating with our unique processes and materials installed by highly skilled specialists.

Ultimately we create what we like to call the perfect all season indoor climate no matter how Cold, Hot or noisy it is outside.

After we insulate, homeowners tell us their entire living experience has improved 100 %

As such, Dolphin Insulation is proposing a modification to the current Massachusetts Building Code R806.5 and 780 CMR 1203.1, 2, 3 to be inclusive of the most current and highly efficient techniques currently available in the home insulation business. Although the current code is not exclusive, the language is open for interpretation thus leaving too much variable interpretation from one town to the next. Our end goal with this proposed modification is to provide customers with improved climate control in their home or business thus providing comfort while saving money and reducing greenhouse gases.

We are proposing to include in Mass Code an alternative method and practice to insulate non vented roof assemblies. The alternative method and practice is to utilize an impermeable containment membrane to contain between *it (containment fabric) and the roof sheathing at least* 12 inches of cellulose insulation at a 4 lb per cubic foot density. Smart Vapor Retarder Membrane has an air permeability of 0.00025L/s-m^2 at 75 psf, far below the board's recommendation of 0.02L/s-m^2 The densely packed cellulose in this configuration is air impermeable and exceeds the air flow standards set forth in ASTM E 2178 or E283. CMR R202. We are not promoting any products specifically but we are focused on the technique.

Attached to this proposal you will find the following evidence to substantiate our request:

- Building Code Appeal from May 25, 2017
- Home Owner Ann Testarmata Letter
- GWR Engineering, PC Report,
- OmniSense document of moisture readings from home in Arlington MA
- Additional moisture readings from New England states
- Table of Contents for Cellulose Insulation

Sincerely,

Christopher Alphen, GC

CHARLES D. BAKER
GOVERNOR

KARYN E. POLITO
LIEUTENANT GOVERNOR

JAY ASH
SECRETARY OF HOUSING AND ECONOMIC DEVELOPMENT

Commonwealth of Massachusetts
Division of Professional Licensure
Office of Public Safety and Inspections
1 Ashburton Place, Rm 1301 • Boston • Massachusetts • 02108

JOHN C. CHAPMAN
UNDERSECRETARY OF CONSUMER AFFAIRS AND BUSINESS REGULATION

CHARLES BORSTEL
COMMISSIONER, DIVISION OF PROFESSIONAL LICENSURE

Date: May 25, 2017

Name of Appellant: Ann Marie Testamata

Service Address: Christopher Alphen
Dolphin Insulation, Inc.
410 Great Road
Littleton, MA. 01460

+In reference to: 26 Nagog Hill Road
Acton, MA. 01507

Docket Number: 17-0059

Property Address: 26 Nagog Hill Road
Acton, MA. 01507

Date of Hearing: May 4, 2017

Enclosed please find a copy of the decision on the matter aforementioned.

Sincerely:

BUILDING CODE APPEALS BOARD

Patricia Barry, Clerk

cc: Building Code Appeals Board, Building Official

TELEPHONE: (617) 727-3200 FAX: (617) 727-5732 http://www.mass.gov/dps

COMMONWEALTH OF MASSACHUSETTS

SUFFOLK, ss.

BUILDING CODE APPEALS BOARD
DOCKET NO. APP-BCAB17-0059

Ann Marie Testarmata,
Appellant
v.

Town of Acton,
Appellee

DECISION

Introduction

This matter came before the State Building Code Appeals Board ("Board" or "BCAB") as a result of an appeal application filed pursuant to G.L. c. 143, § 100 ("Application"). Appellant Ann Marie Testarmata sought review of how 780 CMR R806.4 applies to the installation of attic insulation in her existing single-family dwelling located at 26 Nagog Hill Road, MA. (Appeal").

Procedural History

On or about March 6, 2017, a Building Inspector for the Town of Acton issued a letter that sets forth his conclusions about why the installation of insulation in the roof assembly of Appellant's house did not comply with 780 CMR R806.4. He found that the type of insulation used was "air-permeable" and that the installation did not comply with 780 CMR R806.4, 5, 5.2 which specifies:

> Air-permeable insulation only. In addition to the air-permeable installed directly below the structure sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing as specified in Table R806.4 for condensation control. *780 CMR R806.4, 5, 5.2.*

Appellant filed the Appeal on March 27, 2017. Notice of a hearing about the Appeal was issued to the parties on April 24, via e-mail, for a hearing which was held on May 4, 2017.

The following individuals appeared at the hearing: (for Appellant: Christopher Alpern; Oliver Klein; Paul McDonald; William Hulstrunk); (for Appellee: Tom Moberg, Building Inspector for the Town of Acton); (for the Board: Jeffrey Putnam; H. Jacob Nunnemacher; Steve Frederickson; Board Clerk: Patricia Barry).

We also considered the following: (1) State Building Code Appeals Board Appeal Application; (1A) letter dated March 22, 2017 from Dolphin Insulation, Inc. to the Board, including e-mail dated January 25, 2017, 1:58 p.m. from Ann Marie Testarmata to Chris Alphen; (1B) photographs of exterior of house at 26 Nagog Hill Road and photographs of interior of attic showing parts of insulation installation in roof system; (1C) letter dated March 31, 2016 from Ken Levenson of High Performance Building Supply re: his opinion of "INTELLO Plus membrane" use with dense pack cellulose and compliance with R806.5, including product information and installation instructions; (1D) "Laboratory Report 475BP-SC11535.1-.16-3" re: Physical Properties Testing of INTELLO PLUS, produced by Trinity/ERD for 475 High Performance Building Supply; (1E) "igloo isolation insulation" documents re: Fire Retardant Chemicals and sound-proofing characteristics; (1F) "igloo isolation insulation" Technical DataSheet – ALL BORATE; (1G) letter dated November 10, 2015 from R&D Services to Igloo Cellulose re: test results; (1H) VOC Emission Test Certificate, dated January 20, 2012 by Berkeley analytical; (1I) Interteck test results re: flame spread index and smoke developed index; (1J) Certificate of Compliance issued to Igloo Cellulose Inc. re: emission limits for Igloo Cellulose; (1K) examples of three other projects in which Dolphin Insulation was involved (in Concord, Wellesley, and Newton); (2) letter dated April 24, 2017 from Ann Marie Testarmata re: authorizing Chris Alphen to appear on her behalf at the hearing; (3) two-page document entitled "Super Insulation Moisture Testing Data for Dense Pack Cellulose Walls and Unvented Roof Assemblies" provided by Bill Hulstrunk, dated January 2017; (4) letter dated May 4, 2017 from Bill Hulstrunk on behalf of "UltraCell Insulation".

At the close of the hearing session, we unanimously decided to take the Appeal under advisement and further deliberate, rather than issue an oral decision at that time. Having concluded our deliberations, we issue the following decision.

<u>Findings and Discussion</u>

1. On April 20, 2016, the Town of Acton issued a building permit to add insulation in the attic of the single-family dwelling located at 26 Nagog Hill Road.
2. The dwelling is of Cape-style design, constructed in 1936, containing approximately 2,436 square feet of floor area.
3. Copies of the building permit application and any materials submitted in support of the building permit application were not provided to us. It was not clear how much of the actual design of the insulation system was made known to the Building Inspector during the building permit application process.
4. Prior to the work, the attic walls and roof system were largely not insulated. Although there may be insulation in the attic floor/first level ceiling, there was evidence of heat loss through the roof system, causing ice dams. Based on wanting to reduce energy costs and reduce/eliminate ice dams, Appellant and Dolphin Insulation, Inc. agreed to the installation of the type of system and materials described below.
5. Dolphin Insulation, Inc. installed the insulation system in the roof system, as depicted by the photographs shown in Exhibit 1B, that is the subject of the Appeal.

6. The insulation system consists of the following: sheets of "INTELLO" brand membrane fastened to the rafters and taped together; wood strapping fastened on interior attic side of the "INTELLO" membrane running perpendicular to the rafters; "Igloo" brank cellulose insulation blown into the spaces between the underside of the roof sheathing and the "INTELLO" membrane. Thus, the cellulose insulation completely filled the spaces among the rafters, the underside of the roof deck, and the "INTELLO" membrane. (The same type of insulation system was installed in the gable walls of the attic. See photographs in Exhibit 1B.).

Appellant seeks a variance from, or an interpretation about, the application of 780 CMR R806.4. More specifically, Appellant seeks to have us do the any of the following: (1) render an interpretation that the entire insulation system as installed is "air impermeable" for purposes of subsection 5.1 of 780 CMR R806.4; or (2) grant a variance from subsection 5.2 of 780 CMR R806.4 because the insulation is air-*permeable*, the other requirements of subsection 5.2 cannot be met because of the existing roof coverings, and removal of the insulation system and some type of re-installation to comply with the Code's prescriptive requirements would be a hardship; or (3) approve the insulation system as installed on this house as a performance-based alternative to the Building Code's prescriptive requirements.

Appellant's various representatives provided testimony and written materials about the characteristics of the entire insulation system as installed. Their conclusion was that the insulation system created the functional equivalent of "air-impermeable insulation" for purposes of subsection 5.1 of 780 CMR R806.4. But they did not provide sufficient evidence for us to reach the same conclusion.

To begin, "air-impermeable insulation" is defined as "insulation having an air permanence equal to or less than 0.02L/s-m2 at 75 Pa pressure differential tested according to ASTM E 2178 or E 283." *780 CMR R202*. Cellulose is the insulation that was installed. Notwithstanding the assertion that the cellulose was packed at a higher density between the membrane and roof system than may be typical for packed cellulose insulation, there was not sufficient evidence to conclude that the cellulose, as so packed, complies with the definition of "air-impermeable insulation." Based on the evidence, we find that the cellulose insulation is, by itself, "air permeable".

Because it is "air permeable", requirements of subsection 5.2 apply, which, as quoted above, specify the installation of certain materials on top of the roof deck. In this case, the installation of those materials would require removal and replacement of the existing roof coverings. There was no suggestion that Appellant wants to take those additional steps. (The Building Inspector also suggested that the creation of ventilation between the underside of the roof deck and the top of the insulation, supported by soffit and ridge venting would be acceptable because that would create a vented (rather than the existing "unvented") attic assembly, thus R806.4 would no longer apply. But implementing those changes may be a hardship Appellant is not willing to bear.)

If we were to conclude that "impermeable" characteristics were reached, we would have to conclude that the addition of the "INTELLO" membrane to the air permeable cellulose made the difference. A statement was provided that the "INTELLO" membrane met or exceeded the "air-impermeable" tests set forth in R202. (Exhibit 4). But this statement was not provided by a qualified engineer. Similarly, a statement was provided that the requirements of R806.4 "can be met by using the airtight/thermal insulation systems of Pro Clima INTELLO Plus in combination with dense pack cellulose". (Exhibit 1C). But this statement was not sufficient evidence to support compliance with R806.4 or, instead, a compliance alternative. Although that statement was provided by an individual identified as an architect, there was no evidence about this individual's qualifications. And, even if the membrane were sufficiently air-impermeable, the membrane would not be "air impermeable insulation" as defined and referred to in subsection 5.1.

In sum, the design and installation of the insulation system does not meet the Code's prescriptive requirements set forth in subsections 5.1 or 5.2. Thus, we find that this system could be acceptable only if it there were sufficient evidence of a performance-based compliance alternative to the requirements of 780 CMR R806.4.

Although the evidence suggests that there may be reasons to use this type of insulation system in these particular circumstances, we find that sufficient evidence has not been provided to show professional engineering evaluation of the entire insulation system, in support of a performance-based compliance alternative. Qualified engineering analysis in support of a performance-based compliance alternative would have to be provided for us to consider allowing relief from the requirements of 780 CMR R806.4 in these particular circumstances.

We also recommend that Dolphin Insulation and the parties it consults consider proposing changes or amendments to the Building Code for consideration by the BBRS, with respect to this type of insulation system and installation. Based on what we reviewed in this Appeal, it is likely that these types of systems and installations are being considered for (or may have been installed in) many existing (on possibly new) one or two-family dwellings in the Commonwealth. The BCAB does not have the authority to approve any type of wide-spread application or a change to the Building Code.

Conclusion and Order

Accordingly, based on our findings and conclusions above regarding these particular circumstances, we unanimously concluded to DENY the Appeal. Accordingly the Appeal is DENIED.

H. Jacob Nunnemacher | Jeffrey Putnam, Chair | Steve Frederickson

DATED: May 24, 2017

Any person aggrieved by a decision of the State Building Code Appeals Board may appeal to Superior Court in accordance with G.L. c.30A, § 14 within 30 days of receipt of this decision.

September 8, 2017

Department of Public Safety
Commonwealth of Massachusetts
50 Maple Street
Milford, MA 01757

To Board of Public Safety:

I received a copy of the Board's ruling on my appeal on August 25, 2017, from Chris Alphen of Dolphin Insulation who I had authorized to appear on my behalf at the hearing for Appeal BCAB APP-BCAB17-0059 on May 4, 2017 at 10:30 AM.

I have asked him to represent me and to submit an appeal to the Superior Court within 30 days of receiving your decision on August 25, 2017 providing the additional engineering reports and references that were requested. I am confident that when you review the data and reports provided by Mr. Alphen, you will find relief from the requirements of 780 CMR R806.4 and feel confident in ruling positively on the appeal.

I have a BS in Chemical Engineering and I have studied membrane technology with the world renowned Dr. Sidney Loeb, who created the process of partial reversible osmosis, using membrane technology. This is now used throughout the world to provide fresh water through desalination. The membrane used by Intello is a fascinating membrane and unique in its properties of allowing moisture to permeate in only one direction, allowing any moisture that might be in the densely packed cellulose to escape rather than being entrapped, causing moisture, mold and rot.

I have reviewed data from Intello, provided by Mr Alphen, which reports an air permeability of 0.00025L/s-m^2 at 75 psf, far below the Board's recommendation of 0.02 l/s-m^2. The densely packed cellulose in this configuration is air impermeable and exceeds the airflow standards set forth in ASTM E 2178 or E283. CMR R 202, in your response.

Mr. Alphen has also shared a professional engineer's report, by Gordon W (Bill) Root of GWR Engineering PC of Charlotte, Vermont. In 2013, Mr. Root's report addressed many of the questions you have raised, including a moisture content in the cellulose noted to be 8 % on average, never exceeded 15% in the study, far below the 2013 ASHRAE recommendations of 20%. In addition the insulation tended to dry out in the summer. This study was performed in climate more severe than ours in Massachusetts.

I have worked for the past 35 years as an emergency physician, treating a wide range of illnesses, including asthma, lung disease, allergy, mold related illnesses, environmental related illnesses and cancer. I chose the Intello membrane and densely packed cellulose system offered by Dolphin Insulation after extensive research. I was seeking a system that would provide a clean, healthy method to insulate my 80 year old house that is relatively free of chemical products.

I believe the system installed by Dolphin Insulation achieves this goal. This system has been used and approved in neighboring communities and Dolphin insulation has monitored moisture levels and noted

them to be acceptable. I believe that a review of the data which Mr. Alphen shared with me, will provide you information you require for reconsideration of my appeal.
I will continue to support all further efforts to amend the building code of Massachusetts to support this process of insulation
Please do not hesitate to contact me.

Sincerely,

Ann Marie Testarmata, MD
26 Nagog Hill Road
Acton, MA 01720
978-790-2894
ann.testarmata@gmail.com

CC: Chris Alphen
Dolphin Insulation, Inc
Building Performance Professionals
Littleton, MA 0160
chris@dolphin-insulation.com

TABLE OF CONTENT

The Hygroscopic Properties of Cellulose Insulation and its Relevance in Superinsulated Buildings

Many of our common insulating materials (fiberglass, mineral fiber and foam) are hydrophobic, meaning they don't interact with moisture. Unfortunately, this property can also allow diffusional and airborne moisture to accumulate and linger on surrounding wood and steel building materials, resulting in damage.

Cellulose insulation is made from wood fibers and is hygroscopic, responding much differently to moisture than hydrophobic materials. As moisture levels fluctuate, hygroscopic materials will slowly take on or release moisture as a function of their sorption/desorption curve. Hygroscopic properties also help to distribute moisture evenly throughout the material. The mass of cellulose also allows it to temporarily store moisture and act as a hygric buffer in response to moisture fluctuation. These properties are protective to both the cellulose and adjacent surfaces, by denying damaging organisms the water they need to replicate.

The issue for superinsulated building cavities is that, in the winter, the extra insulation allows the exterior sheathing to get much colder than in conventionally insulated buildings. This can be a problem for fibrous, hydrophobic materials like fiberglass and mineral fiber, since outward diffusional and airborne moisture flows readily pass through these materials. If this moisture cools below its dew point on its way outward, it can condense and/or freeze on the interior side of the building's exterior sheathing. This is problematic since these materials don't interact with water, thus allowing the possibility of mold and rot to develop over time. Very careful detailing of vapor barriers, combined with airtight drywall, is critical with these insulation materials to try to prevent durability issues.

In cellulose-filled superinsulated building cavities, the rate of the inward hygroscopic moisture dispersion is faster than the diffusional moisture drive outward, never allowing the moisture levels to reach dew point. Moisture measurements of 12 inch, dense pack cellulose filled walls at the end of the winter in VT and MA has shown the moisture content of the exterior sheathing typically ranging within 2% of the interior drywall. In buildings with a 50% interior relative humidity, this equates to an approximately 8% moisture content on the interior drywall and 10% moisture content of the exterior sheathing. The ability of cellulose to disperse moisture to the interior, combined with its high installed density of over 3.5 lbs/cuft, makes vapor barriers and airtight drywall unnecessary and, in fact, counterproductive, with dense pack cellulose insulation. This has been borne out by the more than thirty years of experience we have with the first generation of superinsulated cellulose buildings that were constructed in the early 1980's.

These same building science principles are applied when using dense pack cellulose in unvented roof assemblies. The key to their long term performance and durability lies in the installed density being high enough to allow the cellulose to remain in contact with, and protect, the exterior roof sheathing. In a twelve-inch deep rafter bay, an installed density of 3.7 lbs/cuft is required, while in an eighteen-inch rafter bay, an installed density of 4.0 lbs/cuft is necessary. This high density will require several passes, both horizontally and vertically within the rafter bay, to achieve a consistent installed density. The expanded bag coverage chart is used, along with an actual bag count, to allow the installer to verify that the appropriate self-supporting density has been achieved for the rafter depth being insulated.

Moisture modeling software such as dew models and WUFI can be useful in modeling relatively simple single or two-way dimensional moisture flows through hydrophobic materials. These models, however, do not have the mathematical sophistication necessary to model the much more complex moisture flows and hydric buffering that occurs in hygroscopic materials like cellulose insulation.

GWR Engineering, P.C. Consulting Engineers
130 Quarter Mile Rd Charlotte, VT 05445
Tel: (802) 425-2825 Bill@GWRengineering.com

November 18, 2013

Greg Whitchurch
Brook Road
Middlesex, VT

Reference Project: **PH Cottage - Roof Assembly Performance Analysis**
GWR # 1186

Dear Greg,

This UPDATED letter is intended to serve as my response to your request to provide Professional Engineering review of the performance of your proposed non-vented cellulose dense packed insulated flat roof assembly for the Cottage House located on your site.

In summary, my review and analysis has concluded that the mold & moisture risk for the roof as proposed and installed is acceptably low.

The basis of this decision came from a review of the prevalent areas I deemed appropriate for this analysis:

- The science behind moisture migration and retention and ASHRAE Handbook information
- Published data and analysis using WUFI modeling software
- Field data from independent studies performed in similar climates on similar structures and assemblies
- The method and care of the installation
- The monitoring plan and implementation observed

As a PE involved in the design and commissioning of building environmental systems for the past 24 years I have extensive experience in envelope analysis and performance. This was forced upon me due to the inability of environmental systems to meet assumed loads only to find that the construction and design assumptions of building assemblies were being grossly overestimated; poorly presented and inadequately monitored in construction. As the high performance construction market began to emerge in the 90's GWR Engineering was on the forefront working with design teams to assure the definition, interpretation and performance of the envelope was better understood and monitored. This led our teams to garner multiple awards for high performance building design and performance from Efficiency Vermont and then in the State of NH for High Performance Schools (NH CHPS) as well as multiple USGBC LEED certifications.

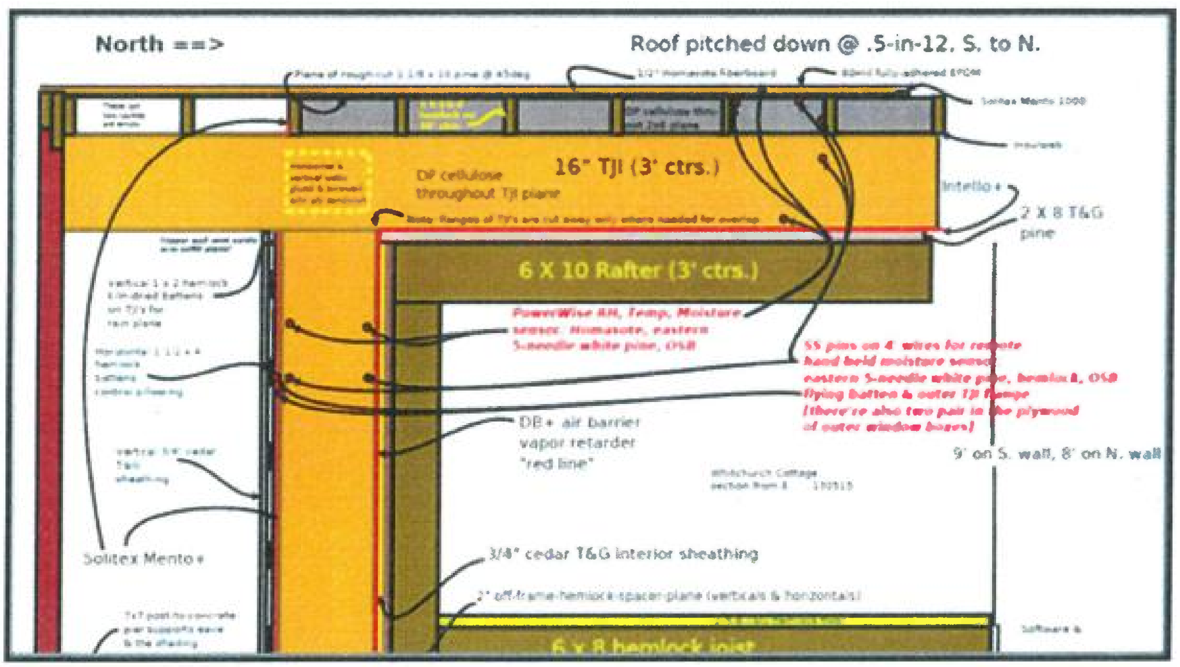
Thru the years I have seen many statements made on performance based on very poor assumptions that were not relative to the specific site or construction assembly. From this I have learned that each and every site must be assessed as a unique entity and success of performance is based on the care of construction as much as it is on the science and engineering behind the design. I have also seen the best plans go bad due to careless and negligent construction practices.

Based on this historical perspective, when you asked for a Licensed Professional's review and statement on the acceptability of this assembly I felt it prudent to approach this from the scientific data side as well as the care and confidence exhibited by those actually performing the installations.

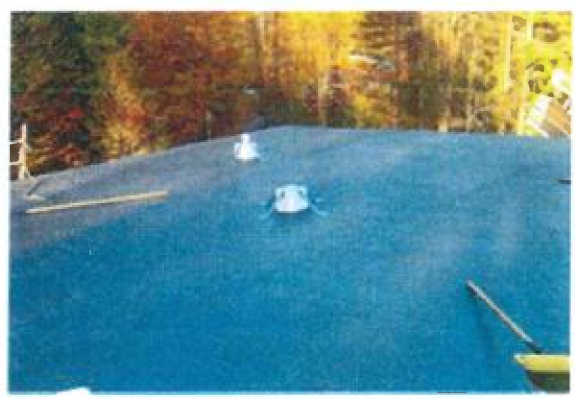
What I have observed in this instance is an exceptional amount of care and attention to detail. You have provided me with detailed information and documentation that clearly shows the care and attention to detail that can assure me that the assumptions I have made concerning performance have the highest probability of success to perform as predicted. This is extremely rare and a major reason why there are so many horror stories out there concerning failures of roof assemblies and why codes are written the way they are in many places. This is complex and tedious work and it is not for every contractor or for mass-production, unfortunately. One day we may get there to fool-proof construction methods but we are not there today. I can attest to this based on the Commissioning I have done on High Performance Buildings in our area over the recent past. Your team is to be commended on the diligence and attention to detail demonstrated to me thru this process and into completion of the assembly. I have full confidence of the success of this project.

Engineer Basis for Acceptability of the Roof Assembly

The design presented to me was detailed in this assembly (as-built) drawing:



Actual 16" TJI & 2x6 roof assembly construction was extremely well documented and photographs show the installation as per the detail:



The basic concern with no venting of the roof assembly is the ability to avoid moisture saturation of materials at the exterior plane that could lead to mold and material deterioration. Multiple articles are found (e.g. " Insight - Don't Be Dense" By Joseph W. Lstiburek, Building Science Corp) that present examples of deterioration in buildings that had flat roofs without venting. On the premise the construction can never be done "right" they make the case all non-vented roofs will fail. The scientific data and analysis I reviewed shows that the moisture levels can be successfully controlled if there is care and attention to the site specific conditions and HOW the construction is done. In new high performance structures the ability to mitigate the amount of moisture transmission thru the building assembly is completely different from the reviewed case studies highlighting failures.

Acceptable levels for moisture and %RH are based on data as presented in the ASHRAE Handbook of Fundamentals, 2013 edition; Chapter 26, pages 16-17 in the sub-section titled "**CRITERIA TO EVALUATE HYGROTHERMAL SIMULATION RESULTS**". These paragraphs address Human Health and Durability of materials, among other factors. The handbook states: (in regards to Human Health and Mold) ***"In recognition of the issue's complexity, the International Energy Agency established a surface relative humidity criterion for design purposes: monthly average values should remain below 80% (Hens 1990)."*** ; and (in regards to Durability of Materials) "***To maintain a safety margin, 20% moisture content is sometimes used as the maximum allowable moisture level.***"

WUFI 5.2 PRO software modeling data analysis provided to me was run by the supplier of the building vapor and air barrier materials being used on this site ((Pro Clima's Intello+, DB+, & Solitex Mento - from FourSevenFive.com).
GWR Engineering does not have this software in house, but reviewed the data sent to determine if it seemed applicable and representative of the site and if the results indicated positive conditions. Software modeling output of the hygrothermal simulation shows that the moisture content of the decking materials do not exceed 20% and drop over time below 10%. This is a very positive result indicating extremely low of potential for structural degradation over time based on the ASHRAE HBF baseline criteria noted above. The interior material surface %RH showed periods above 80% but the annual periods are followed by drying periods down into the 45-55% range with the yearly average around 65% dropping to 60% over time. This data suggests that even though there may not be retained moisture levels to impact material degradation, conditions could exist to generate moisture levels above the 80% threshold. Whether mold will result depends on the actual periods of the higher humidity levels and temperatures. It appears the temperature ranges for these higher periods in the winter are well below the levels at which mold would grow. The 2013 ASHRAE HBF states:*"*

Moisture accumulation below 40°F may not cause mold growth if the material is allowed to dry out below the hygroscopic moisture content for a relative humidity of 80% before the temperature rises above 40°F.". The data seems to show this, but the details on the graphs are difficult to extract exact data from.

Based on this data it seemed somewhat subjective to draw final conclusion on, but seemed favorable to support the basis assumption there exists a low risk for roof failure or issues. Being unfamiliar with this software and comparisons to actual field results I chose not to use this one piece of data as any major indicator of potential results.

GWR Engineering chose to seek and did find engineering studies that duplicated not only the construction type used at this site, but in the similar climate conditions:

The following data being reviewed was obtained from the following University study:

Moisture Accumulation in Cellulose Insulation Caused by Air Leakage in Flat Wood Frame Roofs
D. Derome
Journal of Thermal Envelope and Building Science 2005 28: 269
DOI: 10.1177/1097196305048597

The online version of this article can be found at:
http://jen.sagepub.com/content/28/3/269

University testing was done on various models and results reported. Comments by Bill Root, PE noted:

Table 1. Testing conditions during the experiment.

Period	Day no.	Simulated period	Duration (days)	Indoor temperature (°C)	Indoor RH (%)	Pressure differential (Pa)	Mean outdoor temperature (°C)	Outdoor RH (%)
Pretest	−5–0	–	5	23	50		−3.5	90
1	0–28	Nov–Dec	30	23	50	3.1	−3.5	90
2	28–60	Jan	30	23	40	3.6	−7.0	80
3	60–91	Feb–Mar	30	23	55	3.1	−1.2	90
4	91–112	April	21	21	45	0/3	14.5	45
5	112–143	May	30	21	45	0/2	18.2	40
6	143–172	June	30	23	50	0/1	24	50
7	172–190	July	14	23	50	0/0.5	27.4	72
	Total		190					

The data table above indicates the university testing conditions used. GWR reviewed these conditions and compared to the expected site climate conditions to determine if the study was a match to the actual site, and it appeared it was very close, so close it was felt it was representative of the site.

From Carrier HAP data base:

[Montreal IAP] Monthly Max/Min

	Dry Bulb		Wet Bulb	
Month	Max	Min	Max	Min
Jan	4.4	-5.3	4.2	-5.6
Feb	6.7	-3.1	6.4	-3.4
Mar	13.3	3.6	13.1	3.3
Apr	18.9	9.1	16.1	8.8
May	23.9	14.1	18.9	13.8
Jun	27.8	18.0	20.6	17.4
Jul	29.4	19.7	21.7	18.7
Aug	29.4	19.7	21.7	18.7
Sep	26.1	16.3	20.0	16.1
Oct	20.6	10.8	17.2	10.5
Nov	14.4	4.7	13.9	4.4
Dec	7.8	-2.0	7.5	-2.3

[Barre] Monthly Max/M

	Dry Bulb	
Month	Max	Min
Jan	4.4	-7.3
Feb	6.7	-5.1
Mar	13.3	1.6
Apr	18.9	7.2
May	23.9	12.2
Jun	27.8	16.1
Jul	29.4	17.7
Aug	29.4	17.7
Sep	26.1	14.4
Oct	20.6	8.8
Nov	14.4	2.7
Dec	7.8	-3.9

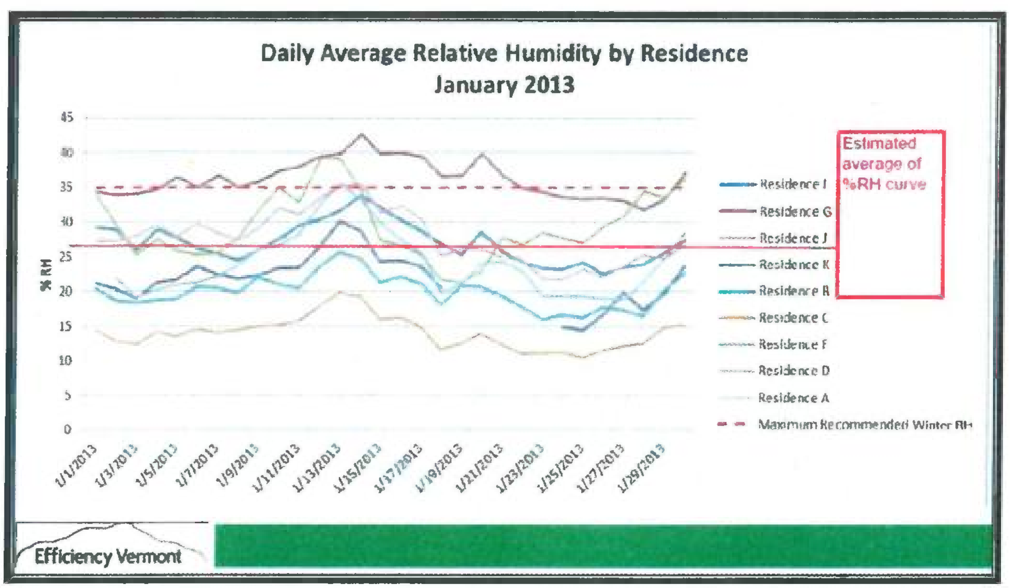
[Montreal IAP] Monthly Max/M

	Dry Bulb	
Month	Max	Min
Jan	40.0	22.4
Feb	44.0	26.4
Mar	56.0	38.4
Apr	66.0	48.4
May	75.0	57.4
Jun	82.0	64.4
Jul	85.0	67.4
Aug	85.0	67.4
Sep	79.0	61.4
Oct	69.0	51.4
Nov	58.0	40.4
Dec	46.0	28.4

Note that these are monthly average min/max values, not extreme point values used for load design.

The university test data used for outdoor air (OA) conditions is closer to Barre, VT which is closer to the actual site data. Correlation is very good and this test model is deemed appropriate in regards to OA conditions when interpretations are made towards results and how they would apply to the site under review.

Interior %RH used in the University test is much higher than seen in typical Vermont residence as reported by EVT sources and presented at 2013 BBD conference:



Data for January suggest the average is somewhere around 28%, significantly lower than the University test conditions for January (40%) and other winter months (50%). Therefore the University test conditions are much more severe than should be expected in the actual building under construction. If the University tests are positive, it is reasonable to assume under less severe conditions the results will be better lowering the risk factor.

The 2013 ASHRAE HBF, and many other sources reviewed, indicate that the effective moisture driven through framed assemblies is directly related to the interior humidity levels and air leakage. Under similar leakage conditions, and when comparing the university testing results to field practice, it is safe to assume that the university study results would indicate higher humidity results. Put another way, the results from this study would be on the extreme side of normal expected field conditions and would allow for extreme conditions outside the anticipated OA and internal conditions for this site. As noted above, under less severe day to day conditions, the field results will be better, lowering the risk factor assumed.

This University Study was further analyzed to see how well it fit against the site and construction underway. It was interesting to find an almost exact match to the PH Cottage construction detail:

Description of Assemblies and their Air Leakage Paths

Four of the five assemblies in each roof were fully insulated with cellulose insulation with no air space between the insulation and the wood roof deck.

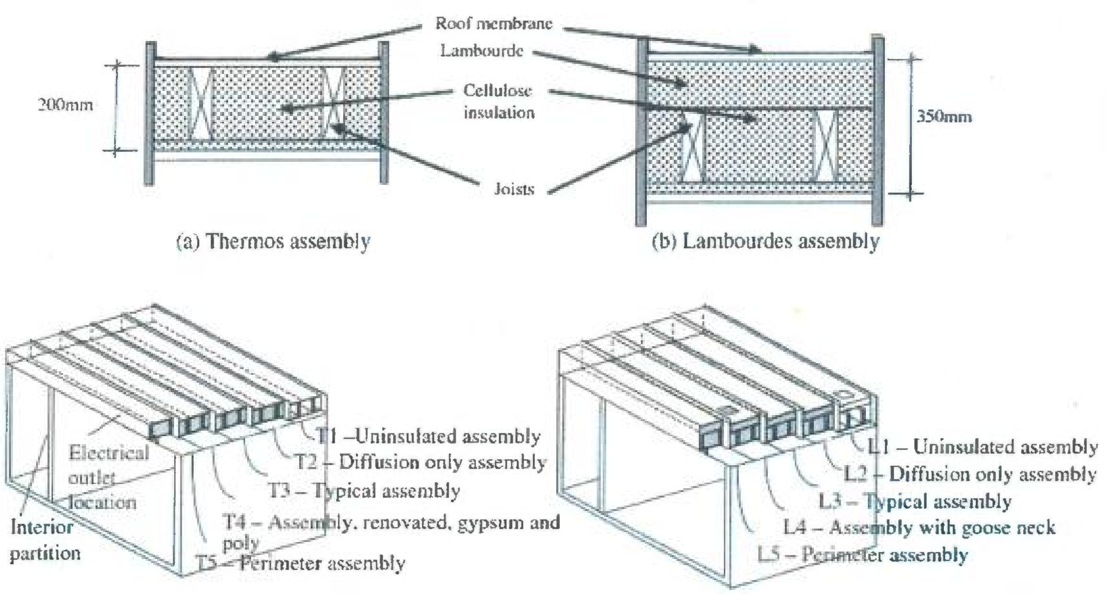


Figure 1. Composition of the two roof assemblies and a schematic of each test hut.

Test assembly details shown above. Item L2 is closest to site conditions, but is much worse as the subject site will have a vapor retarder membrane to limit diffusion and encourage drying. The various conditions created and tested as shown above (L1-L5 & T1-T5) allowed review of performance with and without controlled venting and air leakage. Model 'T4' also presented the results of a vapor barrier's impact. Test results of each of these assemblies are shown in the reproduced 'figure 10' on the next page.

> Initial conditions at the time of the installation of the cellulose, were such that all wood members had moisture contents below 8% and the moisture content of the insulation was between 5 and 5.7%, measured using gravi-

It is assumed that the installed conditions may be slightly higher, maybe 8% (which is what this study's material stabilized to near end of test).

The review of the baseline conditions, materials and methods of this University study show that this study was an extremely close match to the proposed PH Cottage site and construction. It provided some interesting insight to the impact of various construction types on moisture and humidity. Therefore it was deemed to be an excellent demonstration model whose results could be used to ascertain the probability of the performance of the new construction. The following are those results and show that the likelihood of moisture and humidity conditions that could be detrimental to the performance and durability of the structure are extremely low. It is these results that form the basis of the opinion that the risk factor is extremely low.

Results of these University tests and comments follow:

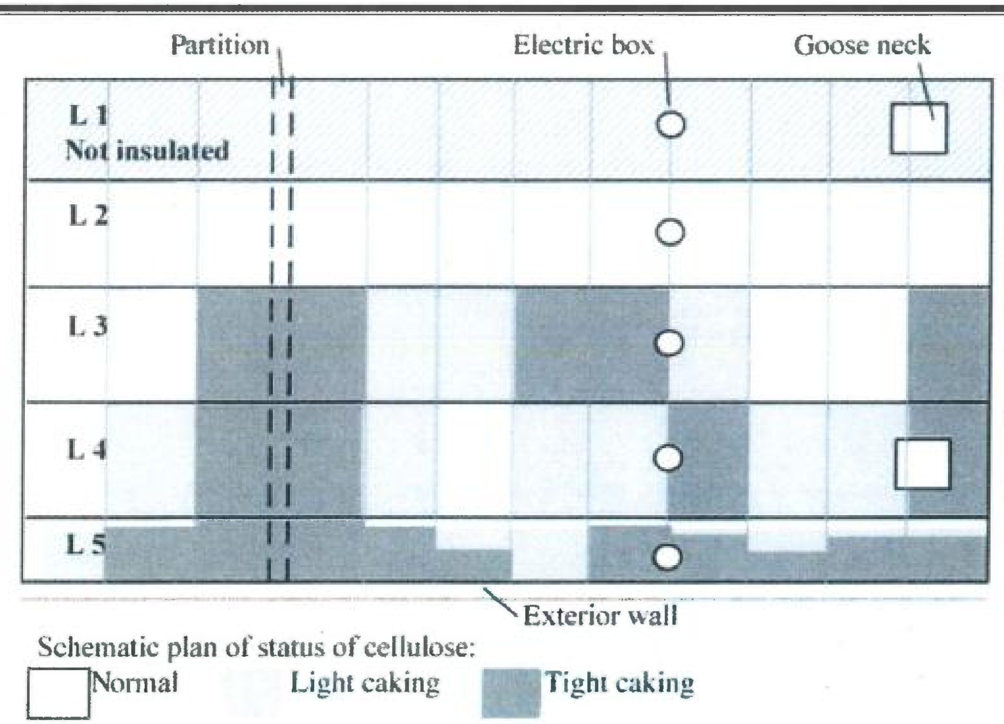


Figure 10. *Status of cellulose in roof assemblies of the lambourdes hut at the end of the test.*

The type L2 assembly, the one closest to the subject site, shows the least caking. Vented assemblies with air leakage show the most caking. This presence of caking was described to be an effect of wetting and drying of the cellulose. Therefore areas with the least caking can be assumed to have seen the least amount of moisture. Limiting air flow limits moisture and caking. This was diffusion only barrier with no vapor barrier indicates very good drying conditions.

The study noted that moisture absorption ability increase with cellulose thickness.

> The data for assemblies in each hut that were subjected to diffusion only is presented in Figure 13. There is no significant difference in the moisture contents between the two huts except that there were slightly higher moisture content maxima in the shallower roof, which can be explained by the fact that the shallower roof had less insulation to absorb the diffusive moisture flow. At low moisture exposure, the moisture content in the cellulose fiber insulation of the two roofs was similar.

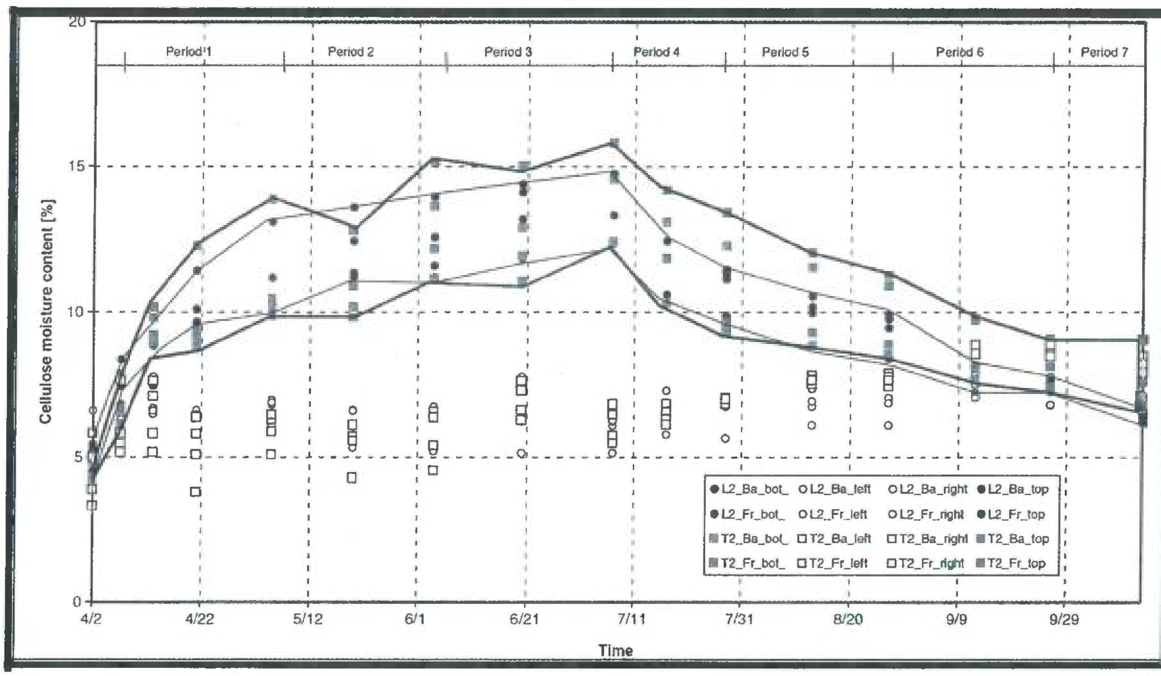


Figure 13. *Moisture content distribution in cellulose insulation in the 'diffusion only' assemblies. The bold-lined zone groups the cellulose samples that were under the deck in the 200-mm high roof (T2). The fine-lined zone groups the samples in the 350-mm high roof (L2). The results for samples that were at the bottom of the assemblies are depicted by open symbols.*

This data also shows the 5% cellulose quickly absorbed moisture from space (steep curve in period 1) yet leveled off closer to expected levels around 8% near the end of the test towards drying periods. There is a slight 2% to 3% increase from period 2 (JAN) to period 4 (April); but the maximum, with 50% interior humidity, never exceeding 15%. Based on ASHRAE 2013 HBF, chapter 25, and other sources, the acceptable upper level for cellulose %RH is 20%. This data shows that this would be the case under the test conditions, which are more extreme that the site under review.

This study made several observations:

> groups specimens were in plastered and painted only roof *T*2. The addition of polyethylene slightly reduced the moisture accumulation, but does not affect the rate of drying.

> assembly was forced down to dry toward the interior. The roof decking was covered with a vaportight roofing membrane, which prevented drying to take place in that direction. As the vapor passed through the assembly to the interior, the moisture content of the cellulose at the bottom of the assemblies was raised slightly. At the end of the test, the moisture content was relatively uniform from top to bottom of the assemblies, for an average moisture content of 8%. This final moisture content indicates the capacity of cellulose insulation to dry during the summer for the climatic conditions simulated.

> assemblies. On the other hand, it was shown that given appropriate conditions, cellulose insulation can also dry. Whether the change of texture affects the insulating performance of cellulose was not assessed. It is also

With similar construction and climatic conditions, yet higher interior humidity conditions (than expected for this site), it can be inferred the University test results would be consistent with the subject site under review in Middlesex, VT. It should be expected, with a high level of certainty, that the assembly would not exceed the desired maximum moisture and humidity levels and drying conditions will be favorable to control moisture within the subject site's flat roof assembly.

It should be further noted that the building was tested for air tightness and exceeded its goal. An energy recovery ventilation system will be installed. These two measures are quality and environmental control measures that assure the interior conditions will match those in the EVT sampled buildings (%RH performance data). The occupants will be 2 elderly people and therefore the moisture generation isn't expected to exceed any of the sample buildings. These points are noted as they infer that the moisture loading and transport drivers will be controlled and minimized. This further reinforces the low risk assessment made by this engineer.

GWR Engineering has concluded that these test results validate the claim that the risk factor for failure of this unvented roof assembly is extremely low.

Engineer Review of the Construction Practices and Monitoring Plan:

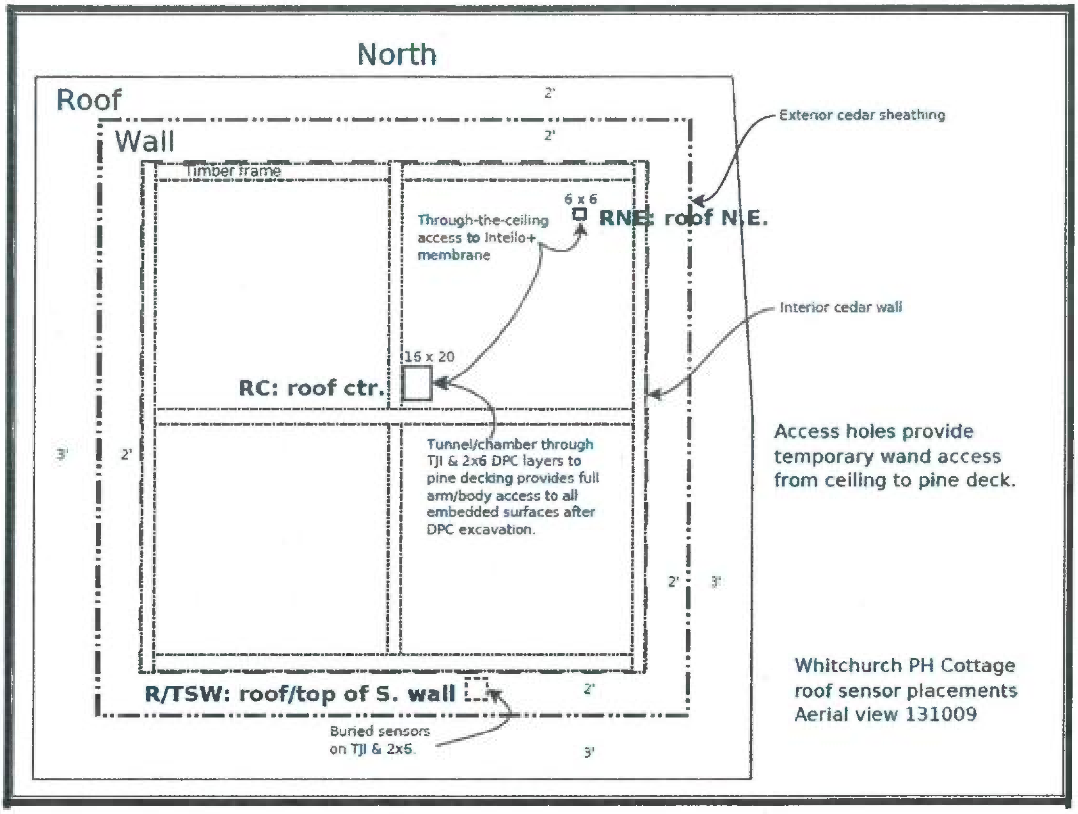
As noted above, this construction team has exceptional pride and diligence in the practice and methods for High Performance Building Construction. After meeting on site and examining some of the construction details, reviewing the photo logs and material product data sheets, it appears this team has met, in my opinion, the high level of quality and detail in the construction that maximizes the success of the performance of the assembly and minimizes the risk associated with any potential failure.

When asked about a monitoring plan and possible corrective actions the team was quick to come up with a response. The fine tuning of the actual methods, materials and installation of sensors to collect data was exceptional. Several contacts were made with people who were doing monitoring to learn from others what works well. This plan was related to me via email:

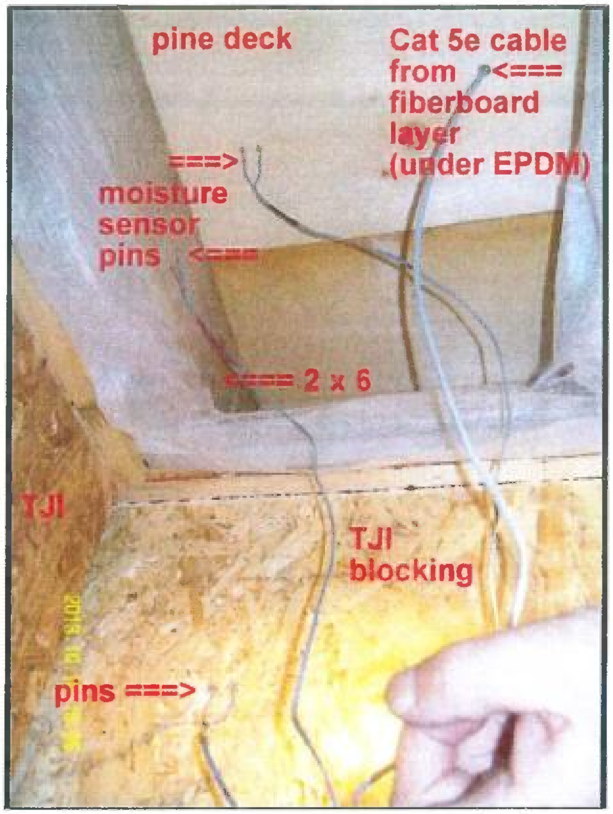
> We've gone with PowerWise because of Peter Schneider's recommendation, ease of acquisition, compatibility & track record with the eMonitor system we're using anyway, etc.(http://www.powerwisesystems.com/) Jacob Deva Racusin of Natural Build (they're straw bale folks) is working on a turnkey wand-based monitoring system that they're anxious to beta in our bldg. (& also adapt to the eMonitor gateway); & Nat'l Fiber is anxious to drop by & plunge some wands from time-to-time. So the access panels (two: hi & low in walls, two: ctr. & corner in roof) will be available for them.
>
> We've placed two sensor pkgs. in the fiberboard layer of the roof assy. & we've completed the fully-adhered EPDM installation. (Whew! We're ready for any weather.) Now we're working out the exact placement of the other 10 sensor pkgs. & their attachment/suspension particulars. As you requested, we're placing sensors directly below the roof deck & we'll describe the parameters to be examined, & which will direct our efforts should remediation be indicated. But we'll also look just outside the interior smart membrane (w/in the DPC cavity); and then mid-way through the cavity; and, in the walls, just inside the WRB (again, w/in the DPC).

Sensors were installed in the roof assembly (and walls) at similar locations as were used in the University study. Access was provided that minimizes the impact to the assembly performance. Installation was detailed in photos for record purposes:

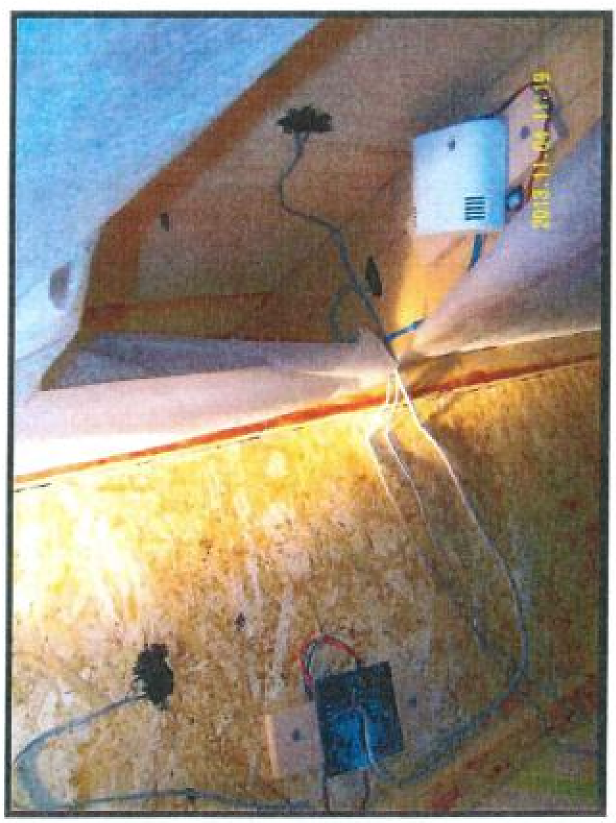
Sensor in the top fiber board material layer.



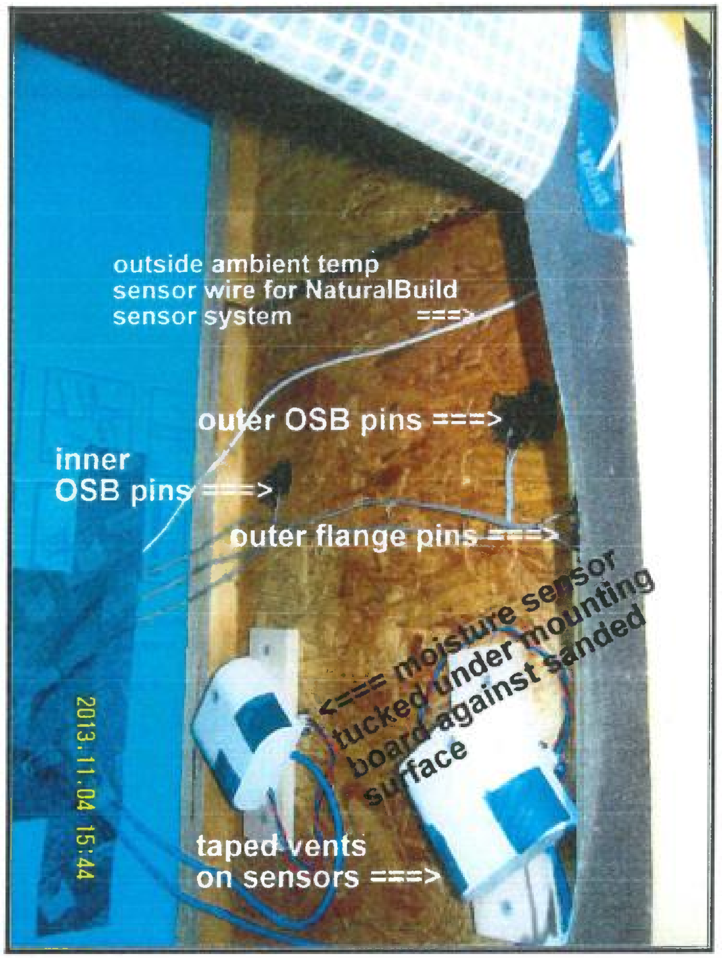
Moisture sensor pins into the pine deck, 2x6 joists and TJI assembly components.



Wired & sealing begun



Additional photo of sensor installations with components identified



In terms of commissioning and continuous measurement and verification the team has done comprehensive work and setup a monitoring system to track the performance of the assembly over time. An 'action plan' was reported to me in the event of a failed condition. This condition would be the reporting of assembly moisture readings over 20% and humidity levels above 80% during temperatures above 40F for those points.

The construction lends itself to easily cutting the roof membrane and adding a vented layer above the top of the roof deck should the determination be made that a vented roof assembly is required.

This concludes my report on the analysis and assessment conclusion that there is a very low risk of failure of this non-vented flat roof assembly. This decision is primarily based on the University Study and the care and workmanship exhibited by the owner and construction team.

I hope the content and analysis methods I have used will satisfy those who are seeking a professional opinion on the construction acceptability. Should you or others need any additional backup documents or references please let me know.

Respectfully,

Bill Root

Gordon W (Bill) Root, Jr PE
ASHRAE High-Performance Building Design Certified Professional

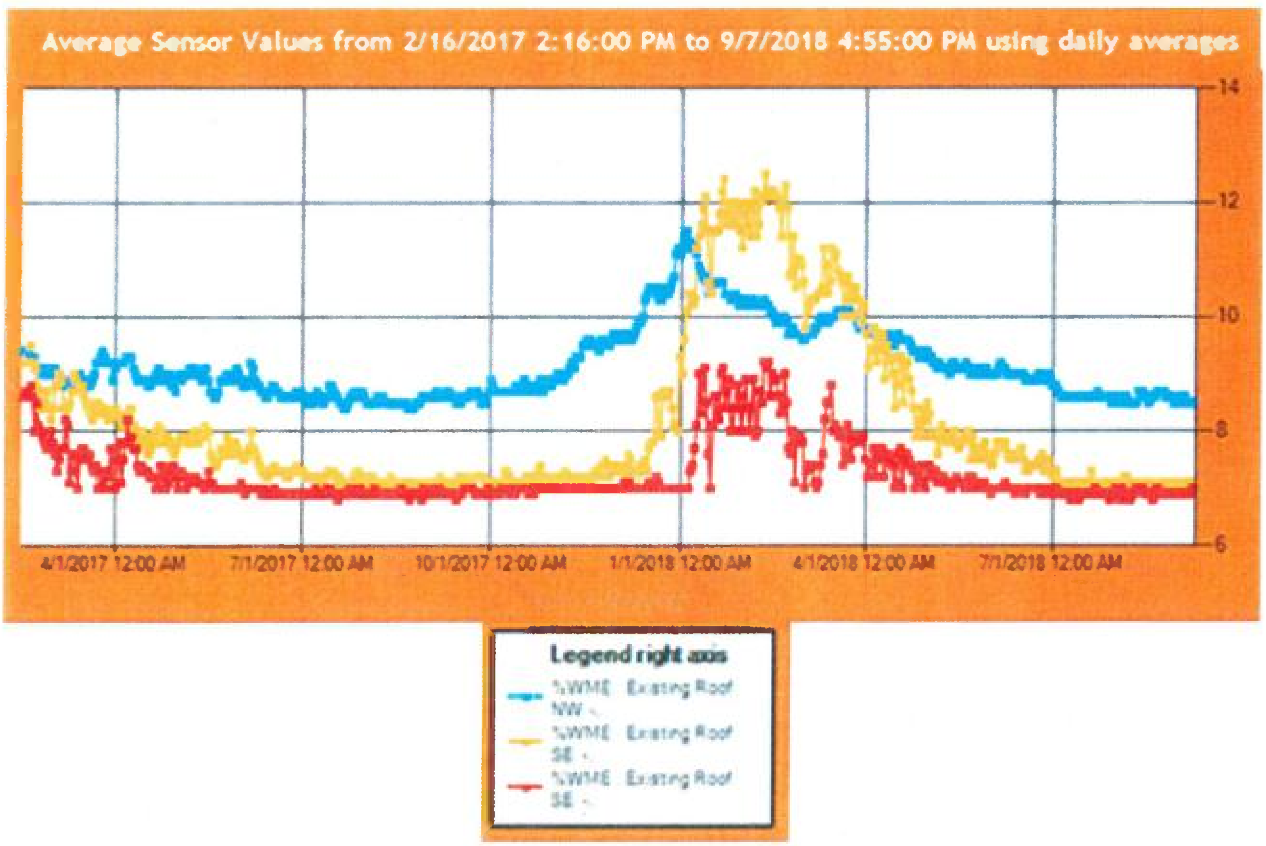
GWR Engineering, PC
130 Quarter Mile Rd
Charlotte VT 05445
Bill@GWRengineering.com

Email received on September 07/2018 from Floris Keverling from 475

Readings from, 02/16/2017 to 09/07/2018

It is important to show the durability of the airseal with the smart vapor retarding properties of the membrane. So it will be good to show the vapor permeance curve.

If you need more data from the monitored house, let me know. I pasted some below (from today)
Working very well and as expected. Staying far below the 15M% cut off (which is very conservative) in the exterior sheathing.



If you need additional information or for us to testify, let us know. We will win them over eventually together.
We might be monitoring another roof in Ma as well (flat roof), only Smart Membrane and insulation (<u>no exterior foam</u>).

Regards,
Floris

OmniSense

Company: 475 High Performance Building Supply **Site:** Arlington project **Time Zone:** Eastern Standard Time

Last Hour ● Last Day Last Week Last Month Last 3 Months Last 6 Months Last Year All Readings

Averaging:

raw data, no avg ▾

Start Date:

1/1/2017

10

:

28

End Date:

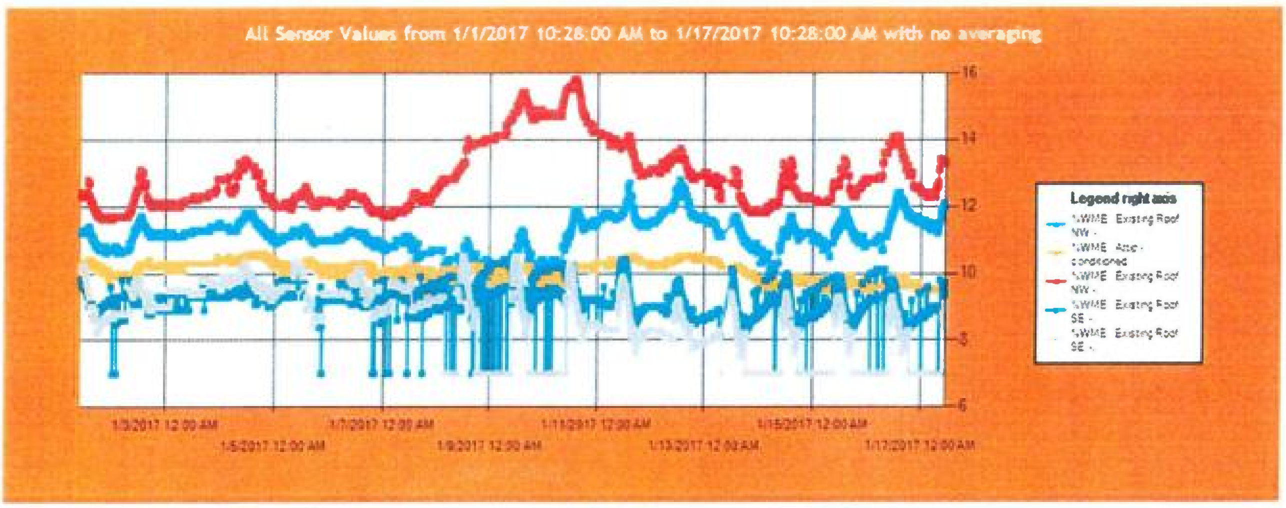
1/17/2017

10

:

28

Show values Enable Recenter Enable Tool Tips Refresh



	%WME : Existing Roof NW - ext. sheathing, high	%WME : Attic - conditioned space	%WME : Existing Roof NW - ext. sheathing, low	%WME : Existing Roof SE - ext. sheathing, high	%WME : Existing Roof SE - ext. sheathing, low
min	9.60	9.30	11.60	7.00	7.00
max	12.80	10.60	15.80	10.40	10.50
diff	3.20	1.30	4.20	3.40	3.50

Automatic Refresh

206F0003	Existing Roof NW - ext. sheathing, high	T(°F)	%RH	AH(GPP)	DP(°F)	✓%WME	Vbatt(Vdc)
206F02E9	Attic - conditioned space	T(°F)	%RH	AH(GPP)	DP(°F)	✓%WME	Vbatt(Vdc)
206F01B8	Existing Roof NW - ext. sheathing, low	T(°F)	%RH	AH(GPP)	DP(°F)	✓%WME	Vbatt(Vdc)
206F01F5	Existing Roof NW - int. INTELLO, mid	T(°F)	%RH	AH(GPP)	DP(°F)	%WME	Vbatt(Vdc)
206F01F9	Existing Roof SE - ext. sheathing, high	T(°F)	%RH	AH(GPP)	DP(°F)	✓%WME	Vbatt(Vdc)
206F01B7	Existing Roof SE - ext. sheathing, low	T(°F)	%RH	AH(GPP)	DP(°F)	✓%WME	Vbatt(Vdc)
206F026E	Existing Roof SE - int. INTELLO, mid	T(°F)	%RH	AH(GPP)	DP(°F)	%WME	Vbatt(Vdc)
206F03A6	New roof NW - ext. sheathing, middle	T(°F)	%RH	AH(GPP)	DP(°F)	%WME	Vbatt(Vdc)
206F03D9	New wall NW - ext. sheathing, middle	T(°F)	%RH	AH(GPP)	DP(°F)	%WME	Vbatt(Vdc)

Cellulose Insulation

For new construction or renovation projects, Cellulose insulation is an unparalleled thermal and acoustical insulation product. We have your health and the environment at heart.

Safe and Healthy

Cellulose insulation is made of recycled newspaper, treated with natural products, is certified low in VOCs, and has a superior resistance to fire, corrosion, humidity, insects and vermin. It's the healthy alternative to traditional insulation products.

Economical

With potential annual savings of up to 25% on heating and air conditioning costs, insulation with cellulose allows for a return on investment within 3 years. It is one of the most profitable investments. You cannot afford not to have it.

Ultra-comfortable

Build it tight, build it right. Cellulose provides a tight building envelope for optimal control of temperature and humidity, thus obtaining natural comfort year-around. You will feel the difference.

No settling

Cellulose installed at a minimum density of 3lbs/ft^3 in cavities by a qualified installer, guaranties 100% no settling of the insulation. Satisfaction Guaranteed.

Soundproof

Compared to other insulation products, cellulose's high density and homogeneity confer it with equal or superior qualities for sound absorption of high and low frequencies, thus offering you an unparalleled acoustical comfort. Enjoy your tranquility.

Eco-friendly

Cellulose is made of 85% recycled newspaper and 15% natural additives. It is the greenest product in the industry.

Cellulose Insulation
Technical Data Sheet ALL BORATE

Product Name: Cellulose Insulation

Technical Name: Loosely packed cellulosic wood fiber

State: Free flowing-wood base

Color: Gray

Odor: None

Dimensional Weight: 1.49 lbs/ft^3

Chemical Composition:

- Newsprint ber C6H10O3
- Boric Acid H3BO3
- Natural additives for dust control

Product Registration:

- Canadian Construction Materials Center (CCMC)
- Technical product / CCMC #08532-L
- Technical product for walls/ CCMC #12835-R
- R & D Services for laboratory tests
- Meets Standards ASTM C-739, 16CFR Section 1209
- Low VOC Emission Certificate #120120-03 (Berkeley Analytical)
- Greenguard Gold Certificate

Ph: At 25oC, 2% solution: 7.8

Packaging: 25 lbs / bag

Installation:

- Cellulose insulation high efficiency relies on air between the fibers, obtained when the cellulose expands during installation.
- Clear up 1 ft2 for 300 ft2 of ceiling of air intake.
- Apply in places where temperature does not exceed 194°F
- Install 3 in or more away from chimneys or heat source.
- Wear a respiratory mask at all times during blowing.
- For soundproofing, contact an acoustical engineer.
- For wall insulation, apply enough product to achieve at least 3 lbs/ft3 density (Recommended 360HD nozzle)
- Do not apply on built-in-surface mounted light fixtures without proper and approved IC protection.

Technical Data Sheet

Installation Chart:

Loose Fill Cellulose Bag Label in Accordance with ASTM C739/C1374

R at 75°F	Thickness (in) Installed	Thickness (in) Settled	Min. Wgt lb/ft²	No adjustment for framing: bags per 1000 ft²	No adjustment for framing: ft² per bag	No adjustment for framing: Minimum Weight lb/sq.ft.
13	4,41	3,97	0,44	12,0	83,5	0,30
19	6,09	5,48	0,65	19,5	51,3	0,49
22	6,95	6,25	0,75	23,4	42,8	0,58
30	9,25	8,33	1,02	33,7	29,7	0,84
38	11,57	10,41	1,30	44,1	22,7	1,10
49	14,77	13,29	1,67	58,4	17,1	1,46
60	17,98	16,18	2,05	72,8	13,7	1,82

The installed thickness data was generated with a Krendl model 500, using air setting 63,5 and gate setting 5. May vary according to ambient temperature and humidity.

Final results will vary according to the application technique, the equipment and the hose used.

Thermal Resistivity

- ASTM C518-10
- R = 3.725 per inch

Surface Combustion Specifications:

- ASTM C739-11 and ASTM E970-14
- Greater than 0.12 W/cm2

Smoldering Combustion:

- ASTM C739-11, section 14
- Less than 15%

Absorption of Moisture Vapor:

- ASTM C739-11, section 12
- Less than 20%

Corrosiveness:

- ASTM C739-11, Section 9
- No perforations on Aluminum, Copper and Steel coupon

Cryptogamic Resistance:

- ASTM C739-11, Section 11 and ASTM C1338-14
- No fungal growth

Odor Emission:

- ASTM C739-11, Section 13
- No odor

Safety Data Sheet

Section 1- Product Information:

Product : Cellulose Insulation
Composition: Secondary wood fiber paper stock (recycled wastepaper) and fire retardants.
Chemical Family: Cellulose Fibers
Effective: 1 Sept. 2015

Section 2 - Hazard Identification:

Hazard Classification: None
Hazard Pictogram: None
Signal Word: None
Hazard Statements: None
Precautionary Statements : None
Other Hazards Which Do Not Result In Classification: None

Section 3 – Composition and Ingredient Information:

Component	CAS#	% By Weight
Cellulose Fiber	65996-61-4	≤87%
Boric Acid	10043-35-3	≤6.5%
Magnesium Sulfate	10034-99-8	≤6.5%
Vegetable Oil		≤1%

Section 4 - First Aid Measures:

Ingestion: Not intended for ingestion. Not a supplement or replacement for human or animal dietary fiber. See physician if ingested.

Skin: Does not normally itch or irritate skin. If skin is broken or sensitive, wash with soap and water.

Inhalation: Dust may irritate nose or throat. If continued difficulty exists, move to fresh air. Seek
Medical attention if conditions persist. Smoking will impair the ability of the lungs to clear themselves of dust.

Eyes: Dust may cause eye irritation. Use liquids suitable to cleanse eye for several minutes. If irritation persists, seek medical attention.

Section 5 - Fire Fighting and Explosion Hazards:

Extinguishing Media: Water or any other agent rated for a wood fire (Type A).
Unsuitable Extinguishing Media: None known.
Specific Hazards: Products of combustion may include but not limited to oxides of carbon
Special Fire Fighting Procedures: Use standard procedures with full protective clothing and respiratory equipment (SCBA).

Section 6 - Accidental Release Measures;

General: Use good housekeeping to minimize dust levels below the exposure limits listed in Section
8. See section 8 for further information on protective clothing and equipment and section 13 for disposal.
In Case of Spill: Shovel or sweep up and place in suitable container for disposal. Minimize dust generation.
Do not dispose in sewers or waterways.

Section 7 - Handling and Storage Information:

General: Avoid contact with skin and eyes. Avoid breathing dust. Do not swallow. Handle and open package with care. Good housekeeping is important to prevent accumulation of dust. When using do not eat, drink, or smoke. Launder contaminated clothing before reuse. Wash hands before eating, drinking, and smoking.
Storage: Keep out of the reach of children. Dry storage is recommended at ambient temperatures and atmosphere. Do not store near open flames or temperatures above 180°F.
Exposure Controls: See section 8.

Section 8 - Exposure Controls / Personal Protection Information:

Exposure Control:

OSHA PEL-TWA = 15 mg/m ^{3} total dust
OSHA PEL-TWA = 5 mg/m^3 respirable faction Cal
OSHA PEL = 10 mg/m^3 total dust
ACGIH TLV-TWA = 10 mg/m' total dust
ACGIH TLV-TWA = 5 mg/m^3 respirable faction

Hand Protection: Wear suitable gloves.
Eye Protection: Safety glasses or goggles are recommended when using product.
Inhalation: Wear suitable respirator for conditions.
Skin and Body Protection: Wear suitable protective clothing.

Other Information: Do not eat, smoke, or drink where material is handled, processed or stored. Wash hands carefully before eating, drinking, or smoking. Handle according to established industrial hygiene or safety practices.

Section 9 - Physical / Chemical

Characteristics

Appearance: Grayish milled fiber
Odor Threshold: No data available. Bulk Density: 1.5 lb/ft^3 per ASTM C739
Boiling, Melting Point: Not Applicable
Vapor Pressure: No data available.
Solubility: Insoluble, dispersible
Auto ignition temperature: No data available.
Decomposition Temperature: No data available.
Partition Coefficient: No data available.

Odor: None to slight paper odor.
pH: 6.0 to 8.0
Evaporation Rate: Not Applicable
Viscosity: Not Applicable **Reactivity in Water:** None
Fiber Flash Point: ≥ 290 degree C
Flammability: Not flammable.
Explosive Limits: No data available.
Freezing Point: No data available.

Section 10 - Stability and Reactivity Data

Reactivity: No dangerous reaction known under conditions of normal use.
Stability: Stable under normal storage conditions.
Possibility of Hazardous Reactions: None under normal use.
Conditions to Avoid: Moisture and incompatible materials.
Incompatible Materials: Chlorates, nitrates, strong oxidizers, and reducing agents.
Hazardous Decomposition Products: May include but not limited to oxides of carbon.

Section 11- Toxicological Information

Routes of Exposure: Inhalation is the most significant route of exposure in occupational and other settings. Dermal exposure is not usually a concern as cellulose and boric acid is poorly absorbed through intact skin. This product Is not intended for ingestion.

Symptoms Related to the Physical, Chemical, and Toxicological Characteristics: Products containing this product are not intended for ingestion. Contact of dust with the eyes causes redness, pain, and inflammation of the eyelids. If inhaled, other symptoms include runny nose, sneezing, and coughing.

Acute Toxicity for concentrated components:

Cellulose:
Oral LD50 (rat) : >5,000 mg/kg of body weight
Dermal LD50 (rabbit) : >2,000 mg/kg of body
weight Inhalation LC50 (rat) : >5.8 mg/L
Dermal irritation/corrosively: Nonirritating, no sensitizing.
Eye irritation: No information found.

Boric acid:
Oral LD50 (rat): 2,550 mg/kg of body weight
Dermal LD50 (rabbit) : >2,000 mg/kg of body weight
Inhalation LC50 (rat) : >2.01 mg/L
Dermal irritation/corrosivity: Nonirritating, nonsensitizing.
Eye irritation: Nonirritating

Germ Cell Mutagenicity:
No information found.

Carcinogenicity:
Cellulose and boric acid are not listed as a known or suspected carcinogens by OSHA, ACGHI, NTP, or IARC.

Reproductive Toxicity:
Borate-treated cellulose insulation contains boric acid and cellulose fiber. Borate-treated cellulose insulation was tested for purposes of hazard classification under the Occupational Safety and Health Administration's 2012 Hazard Communication Standard.
In a study conducted under OECD Guideline 414, there were no developmental effects in rats exposed to up to 270 mg/m^3 (the highest exposure tested). In workers chronically exposed to high levels of borates for several years by way of inhalation, food, and drinking water, there was a clear absence of any reproductive effects.
For Boric acid and substantially similar mixtures (specially, sodium tetraborate pentahydrate and sodium tetraborate decahydrate), the reproductive toxicity is substantially equivalent; therefore, the same hazard category (i.e., no classification for reproductive toxicity) may be applied.

Classification: No classification.

Section 12 - Ecological Consideration:

Not listed as a known marine pollutant according to the IMDG Code. Not known as environmentally hazardous according to UN Model Regulations, ADR, RID, and AON.

Cellulose insulation: No information found.

Phytotoxicity: Boron is an essential micronutrient for healthy growth of plants. It can be harmful to boron sensitive plants in higher quantities. Care should be taken to minimize the amount released to environment.

Persistence and Degradability: Boron is naturally occurring and ubiquitous in the environment. Boric acid decomposes in the environment to natural borate.

Bio accumulative Potential: Not significantly bio accumulative.

Mobility in Soil: This product is soluble in water and is teachable through normal soil. Adsorption to soils or sediments is insignificant.

Section 13 - Waste Disposal:

Dispose in accordance with all applicable federal, state, and local environmental regulations. Dispose as a non-hazardous waste. Not considered hazardous per Resource Conservation and Recovery Act (RCRA) regulations (40 CFR 261). Do not dispose in sewers or waterways.

Section 14 - Transportation Information;

General: Transport in accordance with DOT. Not regulated for transport.

Section 15 - Regulatory Information

Superfund - CERCLA/SARA. This product is not listed under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) or its 1986 amendments, the Superfund Amendments and Reauthorization Act (SARA), including substances listed under Section 313 of SARA, Toxic Chemicals, 42 USC 11023, 40 CFR 372.65; Section 302 of SARA Extremely Hazardous Substances, 42 USC 110002, 40 CFR 355; or the CERCLA Hazardous Substances list, 42 use 9604, 40 CFR 302.

RCRA: This product is not listed as a hazardous waste under any sections of the Resource Conservation and Recovery Act or regulations (40 CFR 261 et seq.)
EPCRA: Not considered a hazardous material and a delayed health hazard by the EPA.
TSCA No: This product does not appear on the EPA TSCA inventory list.
IARC: Not listed on The International Agency for Research on Cancer as a carcinogen.
NTP Annual Report on Carcinogens: Not listed.
Safe Drinking Water Act: This product is not regulated under the SDWA, 42 USC 300g-1, 40 CFR141 et seq.

Section 16 - Other Information

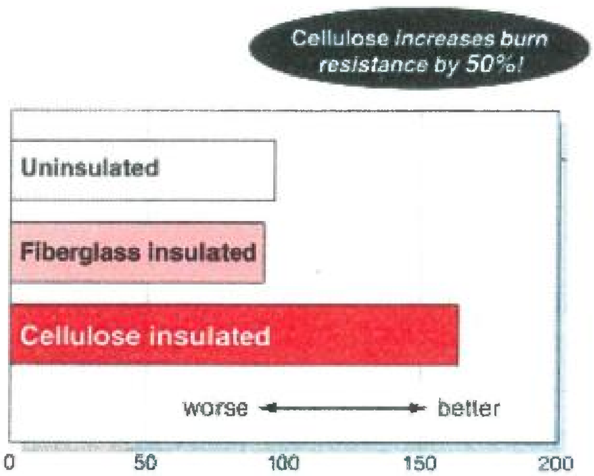
Disclaimer / Statement of Liability: The information presented has been compiled from sources considered to be dependable and is reliable to the best of our knowledge but is not guaranteed to be so. This Safety Data Sheet is offered solely for your information, considerations, and investigations. This SDS is not to be construed as recommending any practice or product in violation of any law or regulation. The user is responsible to determine the suitability of the material for a specific purpose and adopt necessary safety precautions.

This SDS was finalized on September 1, 2015 and is compliant with OSHA HCS/HazCom 2012 Final Rule.
This replaces all previous dated versions.

Fire Retardant

Insulation is an integral part of your home. Depending on the insulation you choose, there may be additional benefits (or dangers) that you may not have considered.

"11 minutes into the burn the ceiling of the uninsulated house collapsed....10 minutes later the ceiling of the fiberglass house also collapsed. The ceiling of the cellulose house did not collapse until 1 hour and 10 minutes after the burn started."
-Insulator's Guide, news account of fire demonstration



Cellulose Exceeds Tough Fire Standards

Cellulose insulation is the only building material in your home that is commonly treated with fire retardants. Applegate Insulation takes this one step further with a unique, two-stage process that injects dry and liquid fire retardants to penetrate the fibers. The result is exceptional insulation that meets or exceeds required fire safety standards and helps protect you and your family.

Cellulose insulation actually helps make homes safer by providing up to 50% better fire resistance than fiberglass. In practical terms, this means that occupants have more time to reach safety in case of fire. Unlike fiberglass, it greatly restricts the amount of oxygen available to support combustion.

Cellulose Insulation Fire Tests

TEST RESULTS

FLAMESPREAD INDEX: 0

SMOKE DEVELOPED INDEX: 0

SPECIMEN DATA . . .

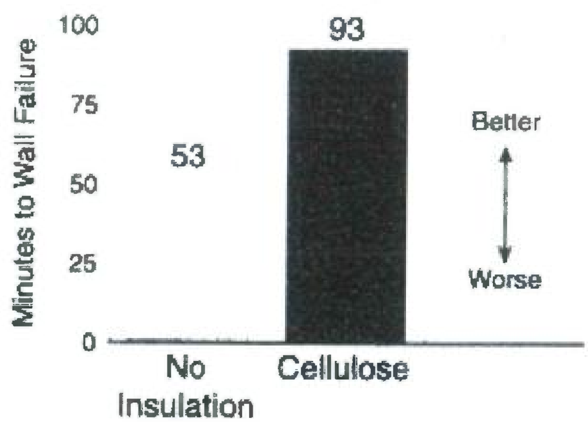
Time to Ignition (sec):	17
Time to Max FS (sec):	37
Maximum FS (feet):	0.2
Time to reach 980F (sec):	Never Reached
Time to End of Tunnel (sec):	Never Reached
Max Temperature (F):	601
Time to Max Temperature (sec):	597
Total Fuel Burned (cubic feet):	47.83
FS*Time Area (ft*min):	2.6
Smoke Area (%A*min):	0.8
Unrounded FSI:	1.4

CALIBRATION DATA . . .

Time to Ignition of Last Red Oak (sec): 43.0

Red Oak Smoke Area (%A*min): 63.8

Figure 1. Wood Stud Wall Test



Scope

These fire tests provide information relevant to architects, builders, and homeowners. Cellulose insulation is an exceptional thermal and acoustical insulation with excellent fire safety properties.

ASTM E119-98 Tests

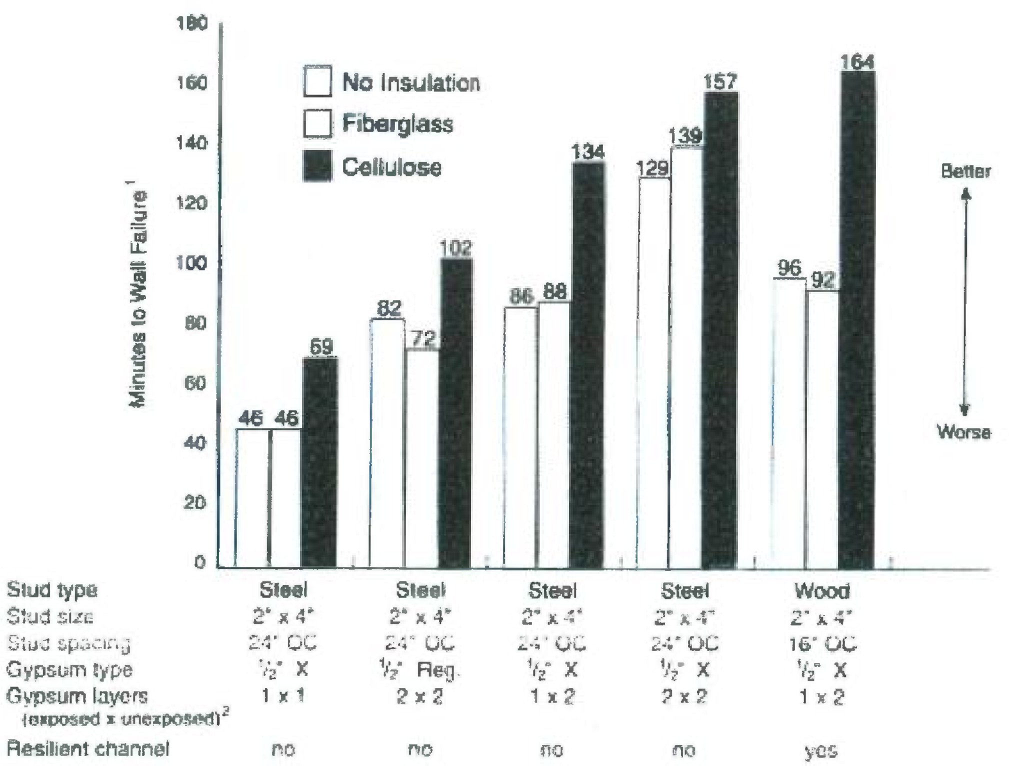
Omega Point, an internationally known NAVLAP certifies laboratory, completed ASTM E119-98 Fire Tests on 2" x 4" wood stud walls framed 16" OC with 1/2" Type X gypsum wallboard on both sides. The tests were performed on uninsulated and cellulose insulated wall sections.

The results are shown in figure 1 (results above). ***The cellulose insulated wall section increased the fire resistance of the wall assembly by 77%!***

Multiple Wall Configuration Fire Tests

The National Fire Laboratory of the National Research Council of Canada, one of the premier building material fire testing facilities in the world, conducted fire resistance tests on wood and steel framed wall assemblies. The tests were performed on uninsulated, fiberglass, and cellulose insulated wall assemblies (results below). ***The cellulose insulation consistently and significantly increased the fire resistance of the walls - by up to 78%!***

Figure 2. Wood and Steel Framed Wall Tests



Straight talk about building insulation and fire

Cellulose is the safest and best insulation commonly used in light construction. This is a problem for those selling insulation products that are not as safe and are much less effective. Somehow, they must convince buyers to accept inferior performance. Some sellers of inferior insulation try to do this by frightening buyers.

Maybe you have heard stories about insulation and fire safety. They all have the same theme: "Our material is 'safe insulation', but their product burns and is the cause of many fires." You may have assumed this is information from an authoritative source.

It isn't. These stories come from the glass industry, a small group of companies selling insulation products that can't compete with cellulose in performance or safety. Here's the truth about insulation and fires.

Insulation Fires

Based on the negative marketing activities of some insulation producers you might conclude that cellulose insulation is one of the leading causes of fires in the U.S. and Canada. This is the first big distortion. "Insulation fires" account for less than one half of one percent of all fires. That is, out of every 200 fires, insulation *of any type*may have something to do with the start of one of them.

The actual figures may be much lower. In Florida in 1990 "insulation fires" amounted to three-tenths of one percent of fires. That's less than one fire out of 300.

What's burning?

The most authoritative and comprehensive study of "insulation fires" was conducted in California after allegedly non-conforming cellulose insulation was found in several hundred homes that were insulated under a community weatherization program. This caused concern, because about 2.5 million California homes had been insulated - most of them with cellulose - under weatherization programs.

Interestingly, the number of residential fires in California decreased significantly during the period when cellulose insulation was being installed in millions of California homes. Still, California utilities, the state fire marshal, and the California Bureau of Home Furnishings wanted to investigate the fire risk of insulation.

Since the key area of concern was attics, the California Task Force used the state fire marshal's computer data base of fire incident reports to isolate fires that started in attics. It further refined this by having the computer identify residential attic fires in which insulation was the first material to burn. The computer found about 160 fires that fit this profile in the 11-year period from 1974 through 1984. This is 0.009% - nine-thousandths of one percent - of all fires. That's one fire out of every 10,000.

This figure raises important questions, because "insulation fires" apparently represent about one half of one percent of all fires - 50 fires in 10,000 - in California and throughout the nation. If only one fire in 10,000 starts in attic insulation, where do the other 49 "insulation fires" start?

The only other location where a significant number of insulation fires can start is walls. Cellulose is often found in attics - especially in California - but, until recently, it was seldom installed in walls. Kraft paper-faced glass batt insulation is widely used in walls.

It would appear that for every "insulation fire" that starts in the area where cellulose is commonly used, 49 "insulation fires" start in areas where paper-faced glass batts are usually found.

A death in Alabama; fires in Canada

The only fatality that has been unquestionably directly linked with an "insulation fire" occurred in Dothan, Alabama, late in the 1970s. A man working in an attic was trapped when insulation caught fire and the flames spread rapidly through the entire attic area. The insulation was kraft paper-faced glass batts.

In Canada similar, but non-fatal, fire incidents resulted in the withdrawal of paper-faced batt insulation from the market. Today such batts, which are among the most commonly-used forms of insulation in the U.S., are no longer sold in Canada.

Paper-faced batts are not fire retardant and they are not covered by the same stringent federal flammability standards that apply to cellulose insulation. Cellulose insulation, whether installed in walls or ceilings, is required by federal law to meet a surface burning standard most authorities regard as equivalent to a Class I flame spread rating.

To qualify as a Class I material, insulation must have a flame spread of 25 or lower as determined by ASTM Standard E-84. Most cellulose products have flame spread ratings well under 25. A famous testing laboratory has measured the flame spread of paper-faced glass batts at approximately 2,000.

Assuring an abundant oxygen supply

Frightening as the flame spread characteristics of paper-faced batts may be, the principal hazard of glass fiber insulation in a fire situation isn't the fuel the facing adds to the fire. It's the unrestricted supply of oxygen fiber glass in all forms assures will be available to burning framing members.

Fiber glass has a wide open structure that is all but transparent to fire and air, and it quickly softens and melts as the fire intensifies. When fire occurs in or spreads into a wall insulated with fiber glass the insulation provides little resistance to the flames and the oxygen that supports them. Wall cavities become convection chambers that literally pump oxygen to the fire. Anyone who has ever built a fire in a fireplace has seen this principle in action.

When walls are insulated with cellulose the scenario is quite different. Cellulose is dense material that is relatively impervious to flames and gases. Because of this, and the fire retardance of the material, fire does not spread as readily into cellulose-insulated walls or ceilings. Walls insulated with cellulose don't readily become draft chambers that deliver oxygen to burning framing members. Cellulose greatly restricts the amount of oxygen available to support combustion in insulated assemblies; fiber glass assures an abundant oxygen supply.

This is why in several fire demonstrations cellulose-insulated buildings have retained structural integrity much longer than fiber glass-insulated buildings. In the most famous demonstration, the ceiling of a fiber glass-insulated structure collapsed 20 minutes after the fire was ignited. The ceiling of a cellulose-insulated structure remained intact for 70 minutes.

In less than two hours the fiber glass structure burned to the ground. After three hours all four walls of the cellulose structure were standing, and the fire had burned out. When the walls were opened there was surprising little damage to the framing lumber.

Recently researchers at the National Research Council of Canada have put scientific authority behind the burn demonstrations. In an extensive research program sponsored by cellulose manufacturers, rock wool manufacturers, and fiber glass manufacturers NRCC scientists tested building assemblies insulated with cellulose, rock wool, and fiber glass.

Cellulose and rock wool, which is also a dense material that doesn't soften or melt at temperatures that occur in light construction fires, were approximately equal -- and very good -- in terms of performance under actual fire conditions. Fiber glass was a distant and rather poor third.

In practical terms this means that in a fire situation cellulose gives building occupants more time to reach safety and fire fighters more time to mitigate damage.

What's the real issue?

In a home insulated to Model Energy Code standards with cellulose, insulation represents only 5% to 7% by weight of the wood-based materials. Cellulose is always fire retardant. The other 93% to 95% are wood products that are seldom fire retardant. Why the focus on the 5% to 7% that is fire retardant?

"Insulation fires" are less than one-half of one percent of all fires. Why do you hear so much about "insulation fires"?

Fire statistics, demonstration burns, and scientific research indicate to the extent that any insulation represents a fire hazard, fiber glass performs worst under actual fire conditions. Why is cellulose so often portrayed as a "fire hazard"?

It's simple. Cellulose outperforms fiber glass as insulation material by such a wide margin -- 26 to 38 percent in a study by Colorado University -- glass insulation can only be sold by creating fear of the superior alternative

Conclusion:
In 9,999 fires out of 10,000 the <u>safe</u> insulation is <u>cellulose</u>!

National Research Council Canada | Conseil national de recherches Canada

NRC · CNRC

Sound Insulation of Load Bearing Shear Resistant Wood and Steel Stud Walls

Nightingale, T.R.T.; Halliwell, R.E.; Quirt, J.D.; Birta, J.A.

IRC-IR-832

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IRC

NRC-CNRC National Research Council Canada

EXECUTIVE SUMMARY

The IRC Acoustics Laboratory has completed the measurement phase of a study of sound transmission through gypsum board walls, which is part of the project "Fire Resistance and Sound Performance of Wall Assemblies - Phase II"

The project was supported by a consortium that included:

- Canadian Home Builders Association (CHBA),
- Canadian Sheet Steel Building Institute (CSSBI),
- Canadian Wood Council (CWC),
- Cellulose Insulation Manufacturers Association of Canada (CIMAC),
- Forintek Canada Corp. (FORINTEK),
- Gypsum Manufacturers of Canada (GMC),
- Institute for Research in Construction of the National Research Council Canada (IRC/NRCC),
- Owens Corning (OC), and
- Roxul Inc. (ROXUL).

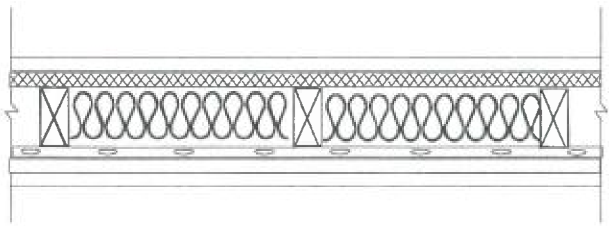
A linked study of fire resistance of wall assemblies has also been completed.
The results have been published as a series of IRC Internal Reports:
IR-729 and IR-806 for wood-framed assemblies, and IR-833 for steel-framed assemblies.

This report presents the sound transmission class (STC) data for a series of walls constructed with industry-standard details. Although some of the specimens were chosen by individual clients to demonstrate performance of specific products, these were combined with a structured series established collectively by the consortium.

The combined set of 58 constructions from this project, together with a similar set of specimens evaluated in a preceding project completed in 1995, provide a database for consistent comparisons of the sound transmission through gypsum board wall systems.

This set of data also provides a basis for empirical prediction methods and for development of improved constructions. More immediately, they provide STC data needed by builders and regulators to select constructions suitable for party walls in multi-family dwellings.

Table WSS-2: Wood studs with one layer of gypsum board plus a shear bracing element on one side, and resilient furring channels plus two layers of gypsum board on the other side



one layer of gypsum board,
shear bracing element (as noted),
38x89 mm wood studs at 406 mm o.c.,
absorptive material (as noted) in stud cavity,
13 mm resilient steel furring channels spaced at 610 or 406 mm o.c.,
two layers of gypsum board.

a) Resilient channels spaced at 406 mm o.c.

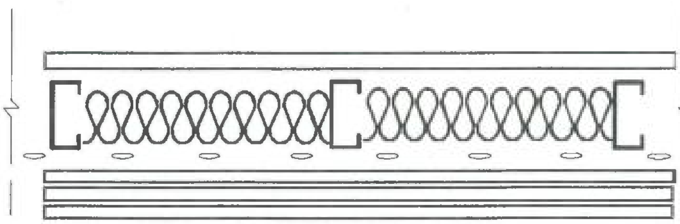
Gypsum Board[1]	Shear Bracing	Absorptive Material	Stud Set[2]	Test Number	STC
12.7 mm regular	12.7 mm OSB (nailed)	glass fibre, 89 mm R12 batt	1	TLA-96-057/058	48
"	12.7 mm plywood (nailed)	glass fibre, 89 mm R12 batt	2	TLA-96-107/108	49
12.7 mm Type X	12.7 mm OSB (nailed)	glass fibre, 89 mm R12 batt	1	TLA-96-045/046	50
"	12.7 mm plywood (nailed)	glass fibre, 89 mm R12 batt	2	TLA-96-113/114	53
15.9 mm Type X	12.7 mm OSB (nailed)	glass fibre, 89 mm R12 batt	3	TLA-96-146M	50
"	12.7 mm plywood (nailed)	glass fibre, 89 mm R12 batt	3	TLA-96-152/153	50

b) Resilient channels spaced at 610 mm o.c.

12.7 mm regular	12.7 mm OSB (nailed)	glass fibre, 89 mm R12 batt	1	TLA-96-053/054	52
	12.7 mm plywood (nailed)	glass fibre, 89 mm R12 batt	2	TLA-96-109/110	51
12.7 mm Type X	12.7 mm OSB (nailed)	glass fibre, 89 mm R12 batt	1	TLA-96-049/050	57
	12.7 mm plywood (nailed)	glass fibre, 89 mm R12 batt	2	TLA-96-111/112	56
15.9 mm Type X	12.7 mm OSB (nailed)	rock fibre, 65 mm R9 batt	1	TLA-96-037M	54
"	"	glass fibre, 65 mm R8 batt	1	TLA-96-035M	55
"	"	cellulose fibre, 89 mm blown	5	TLA-97-082/083	59
"	"	rock fibre, 90 mm R13 batt	5	TLA-97-072/073	56
"	"	glass fibre, 89 mm R13 batt	5	TLA-97-076M	56
"	12.7 mm OSB (nailed)	glass fibre, 89 mm R12 batt	3	TLA-96-144M	55
"	12.7 mm OSB (screwed)	"	6	TLA-97-090M	57
"	12.7 mm OSB (screwed, applied horizontally)	"	6	TLA-97-092/093	56
"	12.7 mm plywood (nailed)	"	3	TLA-96-158/159	54
"	12.7 mm plywood (screwed)	"	2	TLA-96-099/100	55
"	11 mm OSB (nailed)	"	4	TLA-97-058/059	56
"	11 mm OSB (screwed)	"	4	TLA-97-056/057	55
"	9.5 mm plywood (nailed)	"	4	TLA-97-060/061	56

Note: 1. See note on classification and properties of gypsum board on page 40
2. Significance of stud set is discussed in following section on Measurement Process & Precision.

Table LBSS-2(a): 41x92 mm load-bearing steel studs (spaced 406 or 610 mm o.c.), 16 gauge (1.52 mm) or 20 gauge (0.91 mm), with one layer gypsum board on one side, resilient steel furring channels (spaced 406 or 610 mm o.c.) plus two layers gypsum board on other side



one layer of gypsum board,
41x92 mm load-bearing steel studs
16 gauge (1.52mm) or 20 gauge (0.91 mm),
absorptive material (as noted) in stud cavity,
13 mm resilient steel furring channels spaced at 406 or 610 mm o.c.,
two layers of gypsum board.

a) Resilient channels spaced at 406 mm o.c.

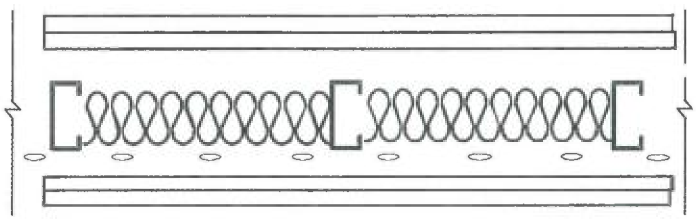
Gypsum Board[1]	Stud Details	Absorptive Material	Set[2]	Test Number	STC
12.7 mm Type X	20 gauge @406 mm o.c.	glass fibre, 89 mm R12 batt	A	TLA-00-103/104	51
"	20 gauge @406 mm o.c.	rock fibre, 90 mm R13 batt	A	TLA-99-127/128	51
"	20 gauge @406 mm o.c.	cellulose fibre, 92 mm blow	A	TLA-00-067/068	51
12.7 mm Type X	20 gauge @610 mm o.c.	rock fibre, 90 mm R13 batt	A	TLA-99-137/138	55
15.9 mm Type X	16 gauge @406 mm o.c.	glass fibre, 89 mm R12 batt	A	TLA-00-083/084	50
	20 gauge @406 mm o.c.	glass fibre, 89 mm R12 batt	A	TLA-00-069/070	51

b) Resilient channels spaced at 610 mm o.c.

Gypsum Board[1]	Stud Details	Absorptive Material	Set[2]	Test Number	STC
12.7 mm Type X	16 gauge @406 mm o.c.	glass fibre, 89 mm R12 batt	B	TL-94-018	53
"	20 gauge @406 mm o.c.	glass fibre, 89 mm R12 batt	B	TL-94-021	54
"	20 gauge @406 mm o.c.	glass fibre, 89 mm R12 batt	A	TLA-00-097/098	54
"	20 gauge @406 mm o.c.	rock fibre, 90 mm R13 batt	A	TLA-99-123/124	52
15.9 mm Type X	20 gauge @406 mm o.c.	glass fibre, 89 mm R12 batt	A	TLA-00-091/092	54

Note: 1. See note on classification and properties of gypsum board on page 40
2. Set A or B denotes measurement results from after or before the facility modification, respectively.

Table LBSS-2(b): 41x92 mm load-bearing steel studs (spaced 406 mm o.c.), 16 gauge (1.52 mm) or 20 gauge (0.91 mm), with two layers of gypsum board on one side, resilient steel furring channels (spaced 610 mm o.c.) plus one layer of gypsum board on other side



two layers of gypsum board,
41x92 mm load-bearing steel studs
16 gauge (1.52mm) or 20 gauge (0.91 mm),
absorptive material (as noted) in stud cavity,
13 mm resilient steel furring channels
spaced at 610 mm o.c.,

one layer of gypsum board.

Gypsum Board[1]	Stud Details	Absorptive Material	Set[2]	Test Number	STC
12.7 mm Type X	16 gauge @406 mm o.c.	glass fibre, 89 mm R12 batt	B	TL94-016	53
"	16 gauge @406 mm o.c.	rock fibre, 90 mm R13 batt	B	TL94-013	53
"	20 gauge @406 mm o.c.	glass fibre, 89 mm R12 batt	B	TL94-019	54
"	20 gauge @406 mm o.c.	rock fibre, 90 mm R13 batt	B	TL94-023	54

Note: 1. See note on classification and properties of gypsum board on page 40
2. Set A or B denotes measurement results from after or before the facility modification, respectively.

Figure 15 compares the cavity insulation type - rock or glass fiber - for 65 mm of insulation in an identical wall assembly. The figure suggests that there may be very little difference due to material type when the cavity is partially filled, but a more extensive comparison with several pairs of specimens would be needed to clearly establish this.

Figure 15:
Effect associated with the type of cavity insulation in a partially filled cavity. Each batt material was nominally 65 mm thick and the cavity was nominally 90 mm deep. (Construction details are identified below the figure title).

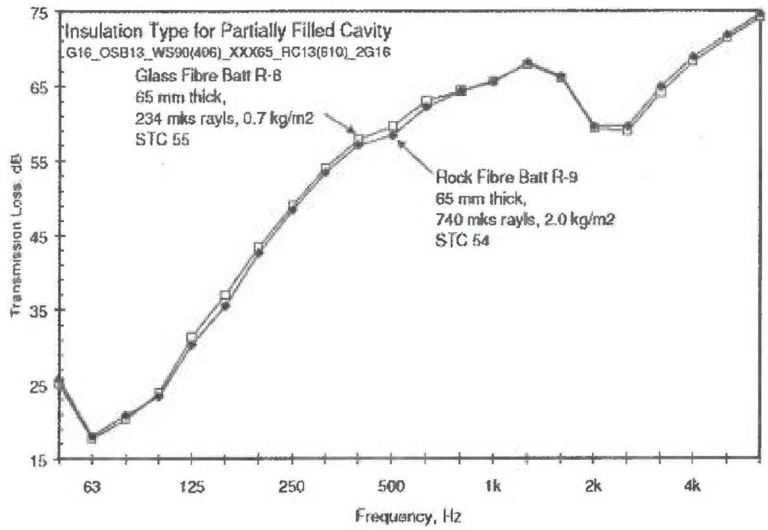


Figure 16 suggests that for frequencies greater than about 350 Hz the transmission loss of a 90 mm wall with a nearly completely filled cavity can be ranked by the airflow resistance of the fibrous material. It is thought that resonant transmission is dominating above this frequency and the additional mass and possible damping introduced by the heavier fibrous materials is having an effect. However, at the lower frequencies, where the STC is determined, the trend is much less clear.

Figure 16:
Effect of type and density of fibrous cavity absorption that completely fills a wood stud shear wall. (Construction details are identified below the figure title).

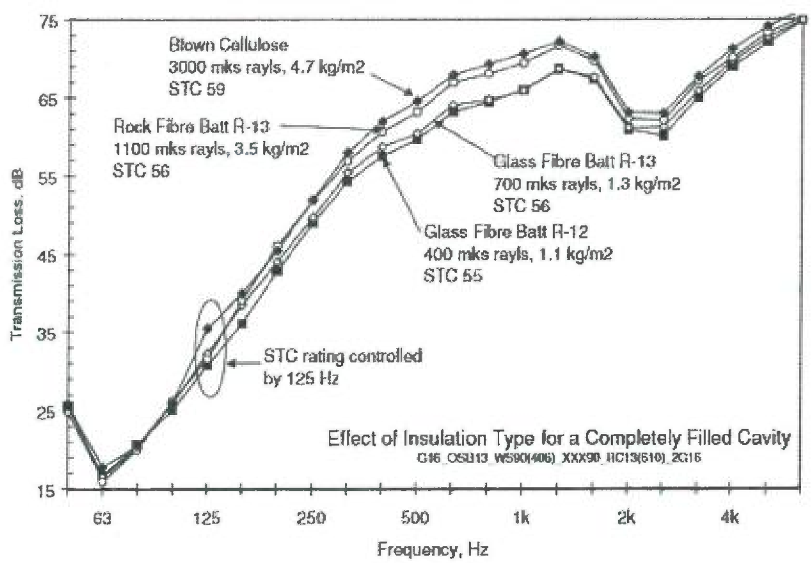


Table A-9.10.3.1.A. (Continued)

Type of Wall	Wall Number	Description	Fire-Resistance Rating		Typical Sound Transmission Class
			Loadbearing	Non-Loadbearing	
	W5b	W5 with • studs spaced 600 mm o.c. • 15.9 mm Type X gypsum board	45 min	1 h	54
	W5c	W5 with • studs spaced 400 mm o.c. • 12.7 mm Type X gypsum board	45 min	1 h	49
	W5d	W5 with • studs spaced 600 mm o.c. • 12.7 mm Type X gypsum board	45 min	1 h	53
	W6	• 38 mm x 89 mm studs spaced 400 mm or 600 mm o.c. • with or without absorptive material • resilient metal channels on one side • 2 layers of gypsum board on each side			
	W6a	W6 with • studs spaced 400 mm or 600 mm o.c. • 89 mm thick absorptive material • resilient metal channels spaced 400 mm o.c. • 15.9 mm Type X gypsum board	1.5 h	2 h	55
	W6b	W6 with • studs spaced 400 mm or 600 mm o.c. • 89 mm thick absorptive material • resilient metal channels spaced 600 mm o.c. • 15.9 mm Type X gypsum board	1.5 h	2 h	58
	W6c	W6 with • studs spaced 400 mm o.c. • 89 mm thick absorptive material • resilient metal channels spaced 400 mm o.c. • 12.7 mm Type X gypsum board	1 h	1.5 h	53
	W6d	W6 with • studs spaced 400 mm o.c. • 89 mm thick absorptive material • resilient metal channels spaced 600 mm o.c. • 12.7 mm Type X gypsum board	1 h	1.5 h	55
	W6e	W6 with • studs spaced 600 mm o.c. • 89 mm thick absorptive material • resilient metal channels spaced 400 mm o.c. • 12.7 mm Type X gypsum board	1 h	1.5 h	56
	W6f	W6 with • studs spaced 600 mm o.c. • 89 mm thick absorptive material • resilient metal channels spaced 600 mm o.c. • 12.7 mm Type X gypsum board	1 h	1.5 h	58
	W6g	W6 with • studs spaced 400 mm or 600 mm o.c. • 89 mm thick absorptive material • resilient metal channels spaced 400 mm o.c. • 12.7 mm regular gypsum board	45 min	1 h	50
	W6h	W6 with • studs spaced 400 mm or 600 mm o.c. • 89 mm thick absorptive material • resilient metal channels spaced 600 mm o.c. • 12.7 mm regular gypsum board	45 min	1 h	52

Table A-9.10.3.1.B. (Continued)

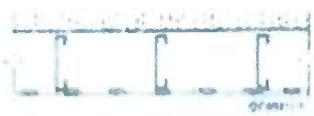
Type of Assembly	Assembly Number	Description	Fire-Resistance Rating	Typical Sound Transmission Class (STC)	Typical Impact Insulation Class (IIC)
	F58e	F58 with • no absorptive material in cavity • 12.7 mm regular gypsum board	-	48	27
	F58f	F58 with • absorptive material in cavity • 12.7 mm regular gypsum board	-	50	30
	F59	• 50 mm concrete • 0.38 mm metal pan with 16 mm rib • on steel joists spaced not more than 600 mm o.c. • with or without absorptive material in cavity • resilient metal channels spaced 400 mm or 600 mm o.c. • 1 layer of gypsum board on ceiling side			
	F59a	F59 with • no absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 15.9 mm Type X gypsum board	-	57	35
	F59b	F59 with • no absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 15.9 mm Type X gypsum board	-	59	35
	F59c	F59 with • absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 15.9 mm Type X gypsum board	-	64	43
	F59d	F59 with • absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 15.9 mm Type X gypsum board	-	66	43
	F59e	F59 with • no absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 12.7 mm Type X gypsum board	-	56	34
	F59f	F59 with • no absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 12.7 mm Type X gypsum board	-	56	34
	F59g	F59 with • absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 12.7 mm Type X gypsum board	-	63	42
	F59h	F59 with • absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 12.7 mm Type X gypsum board	-	65	42
	F59i	F59 with • no absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 12.7 mm regular gypsum board	-	55	34
	F59j	F59 with • no absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 12.7 mm regular gypsum board	-	57	34

Table A-9.10.3.1.B. (Continued)

Type of Assembly	Assembly Number	Description[illegible]	Fire-Resistance Rating[illegible]	Typical Sound Transmission Class[illegible] (STC)	Typical Impact Insulation Class[illegible] (IIC)
	F59k	F59 with • absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 12.7 mm regular gypsum board		62	42
	F59l	F59 with • absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 12.7 mm regular gypsum board	-	64	42
	F60	• 50 mm concrete • 0.46 mm metal pan with a 19 mm rib • on steel joists spaced not more than 600 mm o.c. • with or without absorptive material in cavity • resilient metal channels spaced 400 mm or 600 mm o.c. • 2 layers of gypsum board on ceiling side			
	F60a	F60 with • no absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 15.9 mm Type X gypsum board	1 h	62	36
	F60b	F60 with • no absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 15.9 mm Type X gypsum board	1 h	64	36
	F60c	F60 with • absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 15.9 mm Type X gypsum board	1 h	69	44
	F60d	F60 with • absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 15.9 mm Type X gypsum board	45 min (1 h)[illegible]	71	44
	F60e	F60 with • no absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 12.7 mm Type X gypsum board	1h	60	36
	F60f	F60 with • no absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 12.7 mm Type X gypsum board	1 h	62	36
	F60g	F60 with • absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 12.7 mm Type X gypsum board	1 h	67	44
	F60h	F60 with • absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 12.7 mm Type X gypsum board	45 min (1 h)[illegible]	69	44
	F60i	F60 with • no absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 12.7 mm regular gypsum board	-	60	36

Table A-9.10.3.1.B. (Continued)

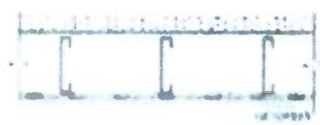
Type of Assembly	Assembly Number	Description	Fire-Resistance Rating	Typical Sound Transmission Class (STC)	Typical Impact Insulation Class (IIC)
	F60j	F60 with • no absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 12.7 mm regular gypsum board	-	62	38
	F60k	F60 with • absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 12.7 mm regular gypsum board	-	67	44
	F60l	F60 with • absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 12.7 mm regular gypsum board	-	69	44
	F61	• 50 mm concrete • 0.38 mm metal pan with 16 mm rib • on steel joists spaced not more than 600 mm o.c. • with or without absorptive material in cavity • resilient metal channels spaced 400 mm or 600 mm o.c. • 2 layers of gypsum board on ceiling side			
	F61a	F61 with • no absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 15.9 mm Type X gypsum board	1 h	62	32
	F61b	F61 with • steel joists spaced 400 mm o.c. • no absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 15.9 mm Type X gypsum board	1 h	64	32
	F61c	F61 with • steel joists spaced 600 mm o.c. • no absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 15.9 mm Type X gypsum board	-	65	29
	F61d	F61 with • absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 15.9 mm Type X gypsum board	1 h	68	37
	F61e	F61 with • steel joists spaced 400 mm o.c. • absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 15.9 mm Type X gypsum board	1 h	66	34
	F61f	F61 with • steel joists spaced 600 mm o.c. • absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 15.9 mm Type X gypsum board	-	71	34
	F61g	F61 with • no absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 12.7 mm Type X gypsum board	1 h	62	32

Table A-9.10.3.1.B. (Continued)

Type of Assembly	Assembly Number	Description(1) (2) (3)	Fire-Resistance Rating(4)(5)(6)(7)	Typical Sound Transmission Class(4)(5)(8)(9) (STC)	Typical Impact Insulation Class(4) (8) (10) (IIC)
	F61h	F61 with • steel joists spaced 400 mm o.c. • no absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 12.7 mm Type X gypsum board	1 h	64	32
	F61i	F61 with • steel joists spaced 600 mm o.c. • no absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 12.7 mm Type X gypsum board	-	64	28
	F61j	F61 with • absorptive material in cavity • resilient metal channels spaced 400 mm o.c. • 12.7 mm Type X gypsum board	1 h	68	36
	F61k	F61 with • steel joists spaced 400 mm o.c. • absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 12.7 mm Type X gypsum board	1 h	64	32
	F61l	F61 with • steel joists spaced 600 mm o.c. • no absorptive material in cavity • resilient metal channels spaced 600 mm o.c. • 12.7 mm Type X gypsum board	-	70	34
Roofs					
Wood Roof Trusses	R1	• wood trusses spaced not more than 600 mm o.c. • 1 layer 15.9 mm Type X gypsum board	45 min	-	-
Rating Provided by Membrane Only					
	M1	• supporting members spaced not more than 600 mm o.c. • 1 layer 15.9 mm Type X gypsum board	30 min	-	-
	M2	• supporting members spaced not more than 600 mm o.c. • 2 layers 15.9 mm Type X gypsum board	1 h	-	-

Notes to Table A-9.10.3.1.B.:

(1) For assemblies with a ceiling consisting of a single layer of gypsum board on resilient metal channels to obtain the listed ratings, the resilient metal channel arrangement at the gypsum board butt end joints should be as shown in Figure A-9.10.3.1.-A.

(2) For assemblies with a ceiling consisting of 2 layers of gypsum board on resilient metal channels to obtain the listed ratings, the fastener and resilient metal channel arrangement at the gypsum board butt end joints should be as shown in Figure A-9.10.3.1.-B.

(3) The fire-resistance rating and sound transmission class values given are for a minimum thickness of subfloor or deck as shown. Minimum subfloor thickness required is determined by structural member spacing (see Table 9.23.15.5.A.). Thicker subflooring or decking is also acceptable.

(4) Sound absorptive material includes
(i) fibre processed from rock, slag, or glass, and
(ii) loose-fill or spray-applied cellulose fibre.
To obtain the listed sound transmission class rating, the nominal insulation thickness is 150 mm for rock, slag, or glass fibres or loose-fill cellulose fibre, and 90 mm for spray-applied cellulose fibre, unless otherwise specified. Absorptive material will affect the sound transmission class by approximately adding or subtracting 1 per 50 mm change of thickness. However, no additional sound transmission class value is achieved by adding a greater thickness of insulation than the depth of the assembly.

(5) The fire-resistance rating and sound transmission class values are based on the spacing of ceiling supports as noted. (See also Table Note (9).) A narrower spacing will be detrimental to the sound transmission class rating, but not to the fire-resistance rating.

(6) To obtain the listed rating, the type and spacing of fasteners are as described in and installed in accordance with Subsection 9.29.5. or CSA A82.31-M:

Table A-9.10.3.1.B. (Continued)

(i) fastener distance to board edges and butt ends should be not less than 38 mm, except for fasteners on the butt ends of the base layer in ceilings with two layers (see Figure A-9.10.3.1.-B); and
(ii) fasteners are spaced not more than 300 mm o.c.

(7) See D-1.2.1.(2) in Appendix D for the significance of fire-resistance ratings.

(8) The sound transmission class values given in the Table are for the minimum depth of structural member noted in the description and applicable table notes. To obtain sound transmission class values for structural members deeper than that minimum, add 1 to the sound transmission class value in the table for each 170 mm increase in structural member depth.

(9) The sound transmission class values given in the table are for structural member spacing of 300 mm o.c., unless otherwise noted in the description and applicable table notes. To obtain sound transmission class values for assemblies with structural members spaced more than 500 mm o.c., add 1 to the sound transmission class value in the Table.

(10) The impact insulation class values given are for floor assemblies tested with no finished flooring.

(11) Wood floor joists are:
(i) wood joists with a minimum member size of 38 mm (width) x 235 mm (depth), except as otherwise noted (see Table Note (14)); or
(ii) wood I-joists with a minimum flange size of 38 mm x 38 mm, a minimum OSB or plywood web thickness of 9.5 mm, and a minimum joist depth of 241 mm.

(12) Except where assemblies with wood I-joists are tested according to CAN/ULC-S101, "Fire Endurance Tests of Building Construction and Materials," the fire-resistance rating values apply only to I-joists that have been fabricated with a phenolic-based structural wood adhesive complying with CSA O112.10, "Evaluation of Adhesives for Structural Wood Products (Limited Moisture Exposure)."
For I-joists with flanges made of laminated veneer lumber (LVL), the fire-resistance rating values apply only where the adhesive used in the LVL fabrication is a phenolic-based structural wood adhesive complying with CSA O112.9, "Evaluation of Adhesives for Structural Wood Products (Exterior Exposure)."

(13) The fire-resistance rating value within square brackets is achieved only where absorptive material includes spray-applied cellulose fibre with
(i) adhesive that is capable of providing a minimum cohesive/adhesive bond strength per unit area of 5 times the weight of the material under the test plate when tested in accordance with ASTM E 736,
(ii) a minimum density of 35 kg/m3, and
(iii) a minimum thickness of 90 mm on the underside of the subfloor or deck, of 90 mm on the sides of the structural members, and for cold-formed steel joists, of 13 mm on the underside of the bottom flange other than at resilient metal channel locations.

(14) The fire-resistance rating value within square brackets only applies to assemblies with solid wood joists and is achieved only where absorptive material includes:
(i) fibre processed from rock or slag with a minimum thickness of 90 mm and a minimum surface area mass of 2.8 kg/m2; or
(ii) spray-applied cellulose fibre with a minimum density of 50 kg/m3 and a minimum depth of 90 mm on the underside of the subfloor and of 90 mm on the sides of the floor joists.

(15) The fire-resistance rating, sound transmission class and impact insulation class values given are also applicable to assemblies with 38 mm (width) x 184 mm (depth) solid wood joists.

(16) The fire-resistance rating value within square brackets is achieved only where absorptive material includes:
(i) fibre processed from rock or slag with a minimum thickness of 90 mm and a minimum surface area mass of 2.8 kg/m2; or
(ii) spray-applied cellulose fibre with a minimum density of 50 kg/m3 and a minimum depth of 90 mm on the underside of the subfloor and of 90 mm on the webs or the sides of the structural members.

(17) The fire-resistance rating, sound transmission class and impact insulation class values within the square brackets only apply to assemblies with solid wood joists and are achieved only where absorptive material includes dry-blown cellulose fibre with a minimum density of 40 kg/m3 filling the entire cavity; the cellulose fibre is supported on zinc-coated (galvanized) steel poultry fence fabric conforming to ASTM A 390 which has 25-mm-wide hexagonal mesh openings and 0.81-mm-thick (20-gauge) wire and is attached to wood joists with metal staples having legs that are 50 mm long.

(18) The fire-resistance rating and sound transmission class values are achieved only where absorptive material includes:
(i) fibre processed from rock or slag that fills the joist cavity and has a minimum surface area mass of 2.8 kg/m2, and for structural members at least 270 mm in depth, the fibre includes three layers each of which has a minimum thickness of 90 mm; or
(ii) dry-blown cellulose fibre with a minimum density of 40 kg/m3 filling the entire cavity; the cellulose fibre is supported on zinc-coated (galvanized) steel poultry fence fabric conforming to ASTM A 390 which has 25-mm-wide hexagonal mesh openings and 0.81-mm-thick (20-gauge) wire and is attached to wood joists or wood I-joists with metal staples having legs that are 50 mm or 30 mm long, respectively.

(19) The fire-resistance rating value only applies to assemblies with wood I-joists with flanges with a minimum thickness of 38 mm and a minimum width of 63 mm.

(20) The fire-resistance rating and sound transmission class values are achieved only where absorptive material includes:
(i) fibre processed from rock or slag that fills the joist cavity and has a minimum surface area mass of 2.8 kg/m2, and for structural members at least 270 mm in depth, the fibre includes three layers each of which has a minimum thickness of 90 mm; or
(ii) dry-blown cellulose fibre with a minimum density of 40 kg/m3 filling the entire cavity; the cellulose fibre is supported on zinc-coated (galvanized) steel poultry fence fabric conforming to ASTM A 390 which has 25-mm-wide hexagonal mesh openings and 0.81-mm-thick (20-gauge) wire and is attached to wood joists with metal staples having legs that are 50 mm long.

(21) The fire-resistance rating values given only apply to assemblies with solid wood joists spaced not more than 400 mm o.c. No information is available for assemblies constructed with wood I-joists.

(22) Wood floor trusses are:

Table A-9.10.3.1.B. (Continued)

(i) metal-plate-connected wood trusses with wood framing members not less than 38 mm x 64 mm, metal connector plates not less than 1 mm (nominal) thick with teeth not less than 8 mm long, and a minimum truss depth of 305 mm;
(ii) metal-web wood trusses with wood chords not less than 38 mm x 64 mm, V-shaped webs made from galvanized steel of 1 mm (nominal) thickness with plate areas having teeth not less than 8 mm long, and a minimum truss depth of 286 mm; or
(iii) finger-joined wood trusses with glued finger-joined connections, chord members not less than 38 mm x 64 mm, web members not less than 38 mm x 38 mm and a minimum truss depth of 330 mm, all of which is glued together with an R-14 phenol-resorcinol resin conforming to CSA O112.10.

(23) The fire-resistance rating value within square brackets is achieved only where absorptive material includes fibre processed from rock or slag with a minimum thickness of 90 mm and a minimum surface area mass of 2.8 kg/m^2.

(24) The fire-resistance rating and sound transmission class values within square brackets are achieved only where absorptive material includes dry-blown cellulose fibre with a minimum density of 40 kg/m^3 filling the entire cavity; the cellulose fibre is supported on zinc-coated (galvanized) steel poultry fence fabric conforming to ASTM A 390 which has 25-mm-wide hexagonal mesh openings and 0.81-mm-thick (20-gauge) wire and is attached to wood trusses with metal staples having legs that are 38 mm long.

(25) Cold-formed steel floor joists (C-shaped joists) are members with a minimum size of 41 mm (width) x 203 mm (depth) x 1.22 mm (material thickness).

(26) The fire-resistance rating value within square brackets is achieved only where absorptive material includes spray-applied cellulose fibre with a minimum density of 50 kg/m^3 and a minimum thickness of 90 mm on the underside of the subfloor, of 90 mm on the sides of the cold-formed steel floor joists, and of 13 mm on the underside of the bottom flange other than at resilient metal channel locations.

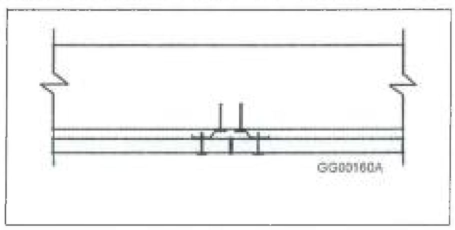


Figure A-9.10.3.1.-A
Single layer butt joint details

Notes to Figure A-9.10.3.1.-A:
(1) Figure is for illustrative purposes only and is not to scale.
(2) The structural member can be any one of the types described in the Table.
(3) Adjacent gypsum board butt ends are attached to separate resilient channels using regular Type S screws, located a minimum of 38 mm from the butt end.

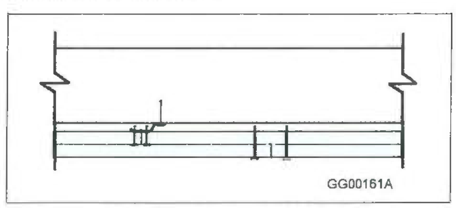


Figure A-9.10.3.1.-B
Double layer butt joint details

Notes to Figure A-9.10.3.1.-B:
(1) Figure is for illustrative purposes only and is not to scale.
(2) The structural member can be any one of the types described in the Table.
(3) Base layer butt ends can be attached to a single resilient channel using regular Type S screws.
(4) Type G screws measuring a minimum of 32 mm in length and located a minimum of 38 mm from the butt end are used to fasten the butt ends of the face layer to the base layer.