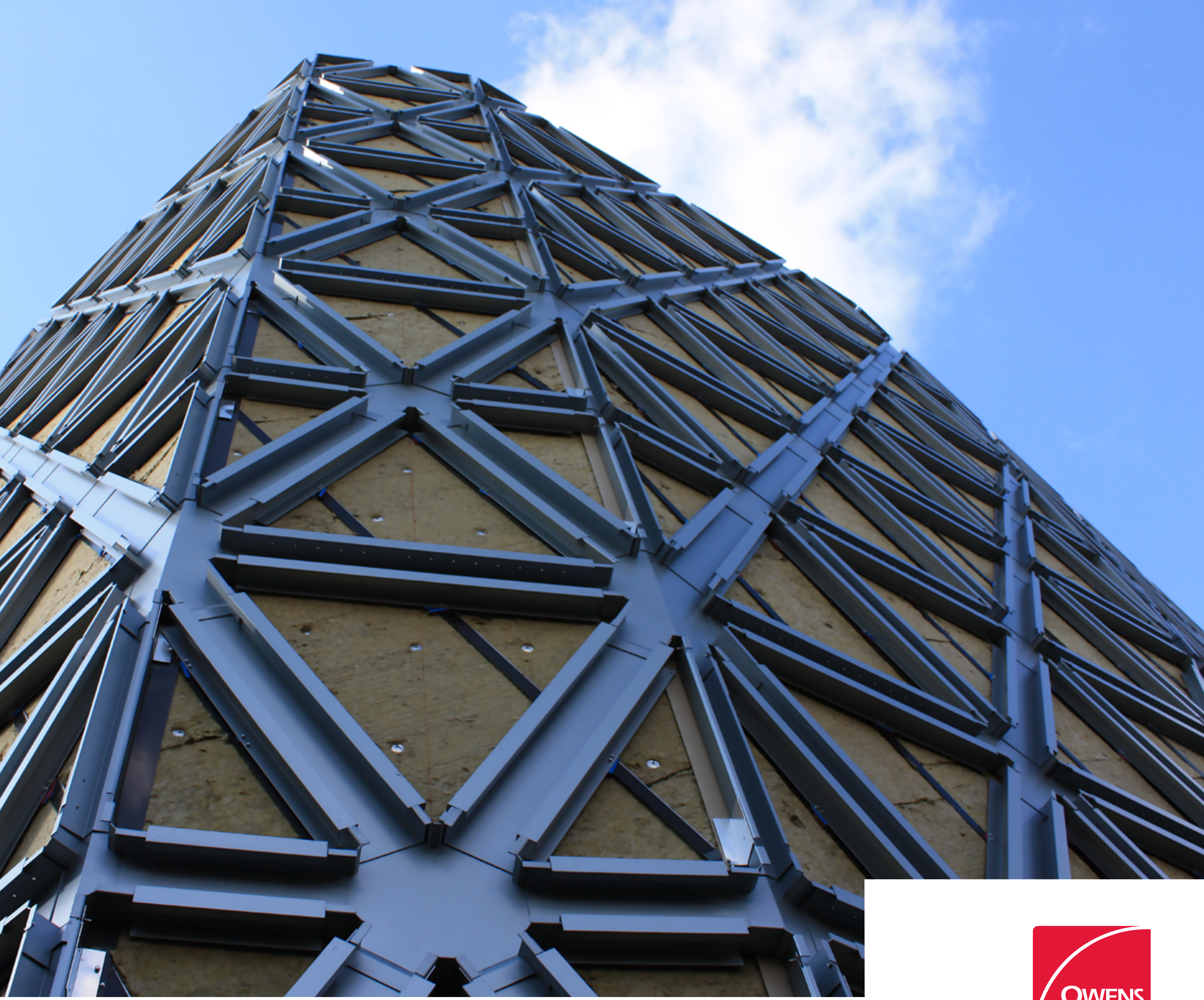


WALL ASSEMBLIES WITH THERMAFIBER® MINERAL WOOL CI EXHIBIT SUPERIOR MOISTURE PERFORMANCE ACROSS THE US

This paper is presented in good faith and believed to be appropriate based upon the descriptions and information provided herein. It is meant only as an aid in the creation of appropriate building designs and specifications by the architect, builder, designer or specifier of record. Designers should use the results and conclusions from this paper as a guide. However, since actual materials, wall systems, and local climate conditions will vary, it is recommended that designers conduct their own hygrothermal analysis. It is the responsibility of that person(s) to make his/her own determination as to whether a product or system is suitable for use including code compliance, constructability, etc. Neither Owens Corning, nor any of its subsidiary or affiliated companies, assumes any responsibility relative to actual projects and specifically disclaim any and all liability for damages of any nature arising from or related in any way to the suggestions provided or reliance thereon.

ABSTRACT

A growing number of architects and building enclosure specialists believe design work plays a critical role in the new decarbonized world vision. They are certainly not alone. For example, non-profit organizations such as Architecture 2030 [1] are advocating for all new projects, renovations, landscapes, cityscapes, and infrastructure to be designed as carbon-neutral. In a similar fashion, the US Department of Energy is on a strategic path for building electrification with renewables, with the goal of achieving zero energy buildings by 2050.

> "Architectural design for construction now includes more elements that include high thermal performance, sustainability, energy storage, zero carbon emission, and improved durability and resiliency."

Moreover, during the past several years the energy standards and codes have enacted the largest energy efficiency improvements in history. Today, architects are even being asked to design buildings with grid interactive efficient building concepts, high resiliency, capable of energy storage, with the lowest embodied energy, zero carbon emission capable, and with high durability.

Many designers achieve this using a traditional rainscreen assembly, see Figures 1A and 1B, often constructed with 2x4 or 2x6 framing but adds mineral wool continuous insulation (CI) installed outboard of the exterior sheathing. Known for its superior fire resistance, non-combustible mineral wool has been used for years to improve the fire performance of buildings. The focus of this paper is to deploy the best building science to investigate the heat and moisture behavior of mineral wool continuous insulation in above grade walls applications. For years, the IECC and ASHRAE 90.1 energy standard have prescribed continuous insulation for a variety of building types in most every climate zone. Employing mineral wool as the CI significantly enhances building performance. It not only minimizes thermal bridging but can also increase the thermal storage opportunity and reduce the risk of moisture related damage to the enclosure.

Recent testing and evaluations at the Oak Ridge National Laboratory [2] demonstrated the excellent vapor permeance of Owens Corning® Thermafiber® RainBarrier® mineral wool insulation which is most ideal for energy efficient building design. As reported in this study, the vapor permeance of these products is a feature that lowers the risk of potential moisture issues in the exterior wall assembly.

Deploying state-of-the-art hygrothermal analysis, this unique study illustrates that the use of permeable exterior mineral wool insulation outperforms other exterior CI systems with respect to moisture durability issues like corrosion and mold growth when compared to vapor impermeable insulations such as foil faced polyisocyanurate foam insulation. **In climate zones across the US, moisture performance of the building enclosure was substantially improved by allowing bi-directional drying (drying both to the interior and exterior) when Thermafiber® RainBarrier® mineral wool insulation was used in combination with a vapor permeable water-resistive barrier (WRB).**

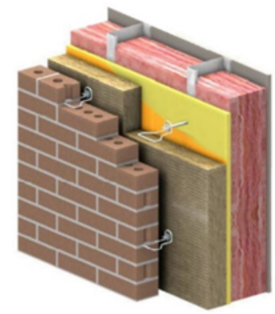


FIGURE 1A — Owens Corning Enclosure Solutions Masonry Veneer Wall with Mineral Wool Continuous Insulation

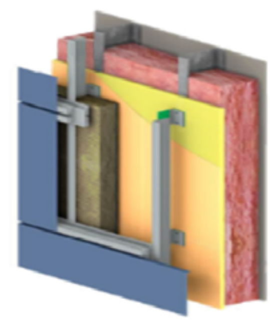


FIGURE 1B — Owens Corning Enclosure Solutions Metal Panel Clad Wall with Mineral Wool Continuous Insulation

INTRODUCTION

Architects are confronted with ever more energy and environmental conscious consumers. One important means of improving the thermal performance of the building envelope is using exterior CI which greatly reduces the impact of thermal bridges caused by structural elements (e.g., steel framing). CI has become standard practice in codes and standards throughout the country. ASHRAE Standard 90.1 and the International Energy Code (IECC) Energy standards are the main drivers behind the evolution of CI in building walls from "non-existent" to a mainstream "common practice."

ASHRAE 90.1 first introduced a prescriptive recommendation for CI in 1999. Since 1999, the prescriptive R-value requirements for CI have moved further south, eventually reaching all the way to Climate Zone 1 (southern Florida), while CI R-value recommendations for the remaining climate zones have steadily risen. Per the 2018 IECC energy code, metal framed wall assemblies in Non-Residential buildings now require a minimum of R5 CI in Climate Zones 1&2, and R7.5 CI in Climate Zones 3-8 (see **Table 1**).

TABLE 1 — 2018 IECC minimum R-value requirements for Continuous Insulation by Climate Zone.

OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, *R*-VALUE METHOD[a]

CLIMATE ZONE	0 AND 1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	ALL OTHER	GROUP R	ALL OTHER	GROUP R	ALL OTHER	GROUP R	ALL OTHER	GROUP R	ALL OTHER	GROUP R	ALL OTHER	GROUP R	ALL OTHER	GROUP R	ALL OTHER	GROUP R
ROOFS																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal Buildings	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-25 + R-11 + R-11 LS	R-25 + R-11 + R-11 LS
Attic and Other	R-38	R-38	R-38	R-38	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-60	R-60	R-60	R-60
WALLS, ABOVE GRADE																
Mass	R-5.7ci[b]	R-5.7ci[b]	R-5.7ci[b]	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal Building	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-17ci	R-13 + R-19.5ci	R-13 + R-19.5ci	R-13 + R-19.5ci
Metal Framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-10ci	R-13 + R-10ci	R-13 + R-12.5ci	R-13 + R-12.5ci	R-13 + R-12.5ci	R-13 + R-15.6ci	R-13 + R-18.8ci	R-13 + R-18.8ci
Wood Framed and Other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R3.8ci	R-13 + R-7.5ci or R-20 + R3.8ci	R-13 + R-7.5ci or R-20 + R3.8ci	R-13 + R-7.5ci or R-20 + R3.8ci	R-13 + R-7.5ci or R-20 + R3.8ci	R-13 + R-7.5ci or R-20 + R3.8ci	R-13 + R-18.8ci	R-13 + R-18.8ci
WALLS, BELOW GRADE																
Below-grade wall[c]	NR	NR	NR	NR	NR	NR	R-7.5ci	R-10ci	R-7.5ci	R-10ci	R-10ci	R-15ci	R-15ci	R-15ci	R-15ci	R-15ci
FLOORS																
Mass	NR	NR	R-6.3ci	R-8.3ci	R-10ci	R-10ci	R-14.6ci	R-16.7ci	R-14.6ci	R-16.7ci	R-16.7ci	R-16.7ci	R-20.9ci	R-20.9ci	R-23ci	R-23ci
Joist/framing	R-13	R-13	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-38	R-38	R-38	R-38	R-38	R-38
SLAB-ON-GRADE FLOORS																
Unheated slabs	NR	NR	NR	NR	NR	R-10 for 24" below	R-15 for 24" below	R-15 for 24" below	R-15 for 24" below	R-20 for 24" below	R-20 for 24" below	R-20 for 48" below	R-20 for 24" below	R-20 for 48" below	R-20 for 48" below	R-25 for 48" below
Heated slabs[d]	R-7.5 for 12" below + R-5 full slab	R-7.5 for 12" below + R-5 full slab	R-7.5 for 12" below + R-5 full slab	R-7.5 for 12" below + R-5 full slab	R-10 for 24" below + R-5 full slab	R-10 for 24" below + R-5 full slab	R-15 for 24" below + R-5 full slab	R-15 for 24" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.
ci = Continuous Insulation, NR = No Requirement, LS = Liner System.

a. Assembly descriptions can be found in ANSI/ASHRAE/IESNA 90.1 Appendix A.
b. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-f^2 °F.
c. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.
d. The first value is for perimeter insulation and the second value is for full, under-slab insulation. Perimeter insulation is not required to extend below the bottom of the slab.

The insulation market has many choices of insulation products ranging from foam plastics to fibrous board products. While the R-value per inch of these product do vary, these differences are not great, and it is relatively straightforward to meet the CI R-value code requirement simply by specifying the proper thickness of insulation. However, unlike R-value, the vapor permeability of these insulations can vary significantly, by as much as a factor of 1000. Some insulations are vapor impermeable (<0.1 perm), such as foil-faced polyisocyanurate insulation, while others are semi-permeable (1-5 perms) such as foam plastic boards/sprays (Expanded (EPS) and Extruded Polystyrene (XPS)) and some insulation materials are vapor permeable (~30-100 perms) like exterior mineral wool/insulation.

> Moisture physics in wall enclosures is complex, it includes transport in vapor phase, liquid phase, evaporation, condensation, and freeze/thaw mechanisms.

It is important to understand that the type of above grade exterior insulation directly impacts the overall moisture performance of the wall systems. Not only does the choice matter, but in many instances even the choice of the manufacturer of the insulation can matter, as large differences have been observed in hygrothermal material performances between the same type of insulations. This can result in significant differences in moisture performances of the wall system.

THEORY OF VAPOR MOVEMENT IN WALL ASSEMBLIES

To better understand the way moisture moves within construction materials, let's reconstruct the fundamentals of moisture physics. Vapor moves from a location of high concentration of vapor molecules to the location with a lower concentration of vapor molecules. High concentration of vapor molecules results in higher vapor pressures, so like any other physical phenomena, flow happens from the high potential location to the lower potential location. Capillary transport is the liquid water movement through capillary (openings) forces that also occurs in a porous construction material from a high potential to lower potential. Sometimes vapor transport occurs in one direction or liquid transport occurs in the opposite direction. However, it most often takes place in the same direction. Air flow through cracks or through porous materials can occur when air pressure differences exist, which then results in vapor molecule movement along the path of air flow.

This exchange and movement of moisture (vapor phase, liquid phase and air convection) happens 24 hours a day, sometimes towards the inside, other times towards the outside and sometimes towards both the outside and inside.

At any time of the day, there are temperature gradients, air pressures, vapor pressures and capillary pressures that are created based on the differences between inside and outside (weather) environments. As the sun hits the wall, it heats the wall creating temperature differences but also a part of the heat induces water molecules to evaporate and create higher vapor pressures. As the HVAC system operates during the summer period, to keep the occupants cool, it also slows down the movement of vapor molecules in the wall. Depending on the HVAC set point and outdoor conditions, water condensation/accumulation may occur.

Moisture sources within a wall usually originate from either the outside or inside. However, initial conditions due to construction moisture is another critical source of moisture (**Figure 2**). Indoor sources of moisture often depend on the type of building occupancy. For example, apartments and condos where occupants are cooking and showering, will have higher interior moisture loads than typical office spaces.

FIGURE 2 — Construction site moisture.

Outdoor sources obviously are from the ambient air vapor water, and from wind driven rain. The wind driven rain is by far the largest source of water in above grade wall enclosures. However, it depends on the coincidental magnitude of the wind. No wind means little water hitting the side walls of the building thus reducing the water available to be absorbed to the interior by the cladding material. Cladding materials also play an important role as they become storage reservoirs for moisture. Because of this, ASHRAE research funded two projects, ASHRAE TRP 1091 [9] and ASHRAE TRP 1235 [10] studied the importance of ventilated claddings. When a wall system includes a ventilated air cavity with top and bottom vents, ventilation can short circuit (reduce) the inward moisture driven by the sun especially during wet summers but also during the spring, fall and even winter seasons. Night sky radiation cooling at the surface of a wall will also cause moisture to move from the outside ambient environment to condense on the exterior surface of the cladding.

THEORY OF VAPOR CONTROL IN WALL ASSEMBLIES

When designing a wall assembly, there are two principal water vapor control approaches to prevent high levels of moisture which can lead to corrosion and mold. The first is to locate a distinctive vapor control layer to retard the flow ofwater vapor into the wall assembly either from the inside or from the outside (**Figures 3a & 3b**). We call these types of assemblies "vapor control layer" assemblies. Since water vapor moves from high to low concentration, the vapor control layer is placed toward the side of the wall with the highest concentration of water vapor. If this is the interior of the wall, the control layer is typically a vapor retarder. If this is the outside, the control layer can be either the water-resistive barrier (WRB) and/or the exterior continuous insulation. While this strategy sounds simple in theory, given the changing vapor flow dynamics in the wall, this approach can be complicated in practice. Sometimes the best strategies to keep water vapor out under one scenario can trap water vapor under another scenario, e.g., different climate zones, seasonal temperature/moisture variations within climates zones, changes in occupancy (moisture loads), exposure of materials to moisture during construction, etc.

Vapor Control Layer Approaches

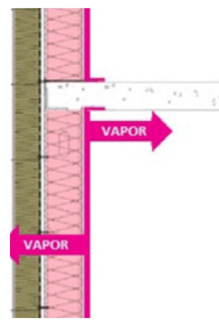


FIGURE 3A — Interior low perm vapor retarder.

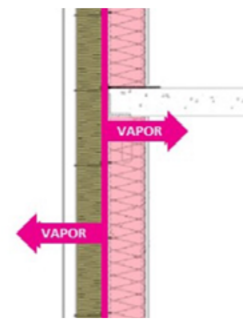


FIGURE 3B — Exterior low perm WRB and/or Continuous Insulation.

Flow Through Approach

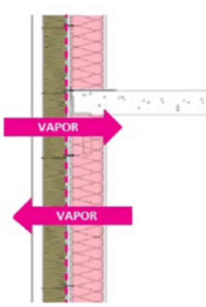


FIGURE 4 — High perm vapor retarder, WRB and Continuous Insulation.

The second water vapor control approach is to let water vapor pass completely through the assembly from the inside out and from the outside in (**Figure 4**). This approach allows the wall to dry to both sides. We call these types of assemblies **"flow-through"** assemblies. In these assemblies, the vapor retarder, water-resistive barrier (WRB) and exterior continuous insulation all have high vapor permeability to allow vapor passage. This approach to water vapor management is very robust given its ability to dry to either side of the wall allowing it to handle the changing vapor flow dynamics within the wall.

Note that mineral wool CI offers designers the flexibility of using either the 'vapor control layer' or the 'flow through' vapor control approach. While mineral wool itself has a high vapor permeability, it can be placed next to a low permeability WRB on the exterior gypsum to provide exterior vapor control if desired. On the contrary, given the low water vapor permeability of foam plastics (especially foil faced products), designers are limited to the 'vapor control layer' approach when using foam CI.

Permeable mineral wool CI offers significant vapor design flexibility to design professionals.

COMMENTS ON AIR BARRIERS

The focus of this study is on the movement of water vapor (vapor diffusion) through building materials and the impact on the overall moisture performance of the wall. It is assumed that designers incorporate an air barrier strategy into their design. In addition to saving energy (reduced air infiltration) the air barrier is also critical to reducing moisture issues since the bulk movement of air can carry large amounts of water vapor. Therefore, in the strictest sense, an air control layer is also a form of vapor control since it controls the transport of moisture-laden air. Often the water-resistive barrier (WRB) is also the air barrier system. WRB's can be both air and liquid-water resistant, while still being vapor permeable. The vapor permeability of the WRB is important to the drying capability of the wall as will be discussed later in this paper.

CODE REQUIREMENTS FOR VAPOR RETARDERS AND CONTINUOUS INSULATION

The 2021 International Energy Conservation Code (IECC), International Building Code (IBC), and International Residential Code (IRC) provide guidance on the use of interior vapor retarders. The code language classifies vapor retarders in three categories based on their permeabilities – Class I (impermeable), Class II (semi-impermeable), and Class III (semi-permeable) (**Table 2**). The code also defines which vapor retarder class can be used in which Climate Zone (**Table 3**). The range of vapor retarder permeabilities allowed from 0.1 to 10 perms (100x) and the permitted Climate Zones provides designers significant flexibility in choosing their vapor control strategy. For example, if a designer elected to use a 'flow through' strategy with a Class III vapor retarder (latex paint) and a high permeability WRB and mineral wool, the code would allow this in all climate zones. Similarly, if the designer preferred to use a 'vapor control layer' approach with a Class II vapor retarder (fiberglass batt with FSK facing), they could do so in all climate zones, except of course in the very humid, southern Climate Zones 1 & 2 where the use of low permeance interior vapor retarder is not a good moisture management practice.

TABLE 2 — 2021 IECC, IBC & IRC Vapor Retarder Classifications.

VAPOR RETARDER MATERIALS AND CLASSES

CLASS	ACCEPTABLE MATERIALS
I	Sheet polyethylene, nonperforated aluminum foil, or other approved materials with a **perm rating of less than or equal to 0.1**
II	Kraft-faced fiberglass batts, vapor retarder paint, or other approved materials applied in accordance with the manufacturer's installation instructions for a **perm rating greater than 0.1 and less than or equal to 1.0**
III	Latex paint, enamel paint, or other approved materials applied in accordance with the manufacturer's installation instructions for a **perm rating of greater than 1.0 and less than or equal to 10.0**

TABLE 3 — Allowable vapor retarder class by Climate Zone (2021 IBC).

VAPOR RETARDER OPTIONS

CLIMATE ZONE	VAPOR RETARDER CLASS		
	CLASS I	CLASS II	CLASS III
1, 2	Not Permitted	Not Permitted	Permitted
3, 4 (except Marine 4)	Not Permitted	Permitted	Permitted
Marine 4, 5, 6, 7, 8	Permitted	Permitted	See Table 1404.3(3)

It should be noted that the tables provided in this paper are meant as a summary of the code language. It is recommended for designers to read the full code language to ensure a thorough understanding of the requirements. For example, the codes do recognize the relationship between thermal and moisture control when exterior continuous insulation is used. The code specifies minimum R-values for CI in colder climates (**Table 4**). Higher R-values of CI raise the overall temperature profile of the wall cavity, thus reducing the risk of condensation even when Class II or Class III vapor retarders are used.

TABLE 4 — 2021 IBC Continuous Insulation R-value requirements.

CONTINUOUS INSULATION R-VALUE REQUIREMENTS WITH CLASS II AND III VAPOR RETARDERS

	FROM TABLE 1404.3.1	FROM TABLE 1404.3(3)
CLIMATE ZONE	**Class II** vapor retarders permitted for continuous insulation with:	**Class III** vapor retarders permitted for continuous insulation with:
3	R-value ≥ 2	N/A
4	R-value ≥ 3 over 2 x 4 wall, R-value ≥ 5 over 2x 6 wall	R-value ≥ 2.5 over 2 x 4 wall, R-value ≥ 3.75 over 2x 6 wall
5	R-value ≥ 3 over 2 x 4 wall, R-value ≥ 5 over 2x 6 wall	R-value ≥ 5 over 2 x 4 wall, R-value ≥ 7.5 over 2x 6 wall
6	R-value ≥ 3 over 2 x 4 wall, R-value ≥ 5 over 2x 6 wall	R-value ≥ 7.5 over 2 x 4 wall, R-value ≥ 11.25 over 2x 6 wall
7	R-value ≥ 5 over 2 x 4 wall, R-value ≥ 7.5 over 2x 6 wall	R-value ≥ 10 over 2 x 4 wall, R-value ≥ 15 over 2x 6 wall
8	R-value ≥ 7.5 over 2 x 4 wall, R-value ≥ 0 over 2x 6 wall	R-value ≥ 2.5 over 2 x 4 wall, R-value ≥ 20 over 2x 6 wall

Finally, a note on the use of Class I vapor retarders on both sides of the wall, such as 6 mil poly film on the inside and a foil-faced foam insulation on the outside. This construction is commonly referred to as a **'double vapor barrier'** wall. The concern with these wall systems is the potential for trapping moisture because the Class I vapor retarders severely restrict the ability of the wall to dry. While building codes do allow this type of construction (cold dry climates) they specifically require the use of approved designs. An approved design is defined as using "accepted engineering practices for hygrothermal analysis."

RESEARCH STUDIES

Designing Wall Assemblies with Mineral Wool CI

The objective of this research study is to assist architects in designing thermally efficient and moisture durable wall assemblies utilizing mineral wool continuous insulation (CI). The scientific approach uses the best available building science tools and material property testing to investigate the heat and moisture behavior of these walls focusing on two questions:

1. Does the high vapor permeability of mineral wool CI improve the drying capability of a wall assembly compared to less permeable insulations such as foam plastic?
2. Can a wall assembly utilizing mineral wool CI, with a permeable vapor retarder and WRB ('flow through' assembly), perform well in all US Climate Zones, e.g., Florida to Minnesota?

Hygrothermal Modeling

Given the complexity of moisture movement within walls, assessing the performance of wall assemblies requires a robust software tool which can calculate the time dependent moisture balance and temperature profile in each material section of the wall. A simple dew point analysis is not up to this task as it is not capable of handling transient thermal/moisture conditions or the complex properties of the materials.

The best solution is to use a hygrothermal modeling program, such as WUFI. WUFI® is an acronym for Wärme Und Feuchte Instationär — which translated means heat and moisture transiency. WUFI uses physical property data of building materials, exterior weather data, and interior temperature/humidity conditions to accurately calculate the thermal and moisture levels throughout the wall on an hourly basis over the course of multiple years. Indeed, excellent agreement has been found in a number of complex research projects using WUFI and WUFI-like software over the past 10 years validating the physics involved. [5], [9] and [10].

WUFI provides realistic calculations of the transient heat and moisture transport in walls.

For Question #1 (impact of CI permeability on the drying time of wall assemblies), we utilized **WUFI-Pro** version 6.5 for the analysis. WUFI-Pro is an hourly, one-dimensional hygrothermal program which accounts for built-in moisture, driving rain, solar radiation, long-wave radiation, capillary transport, etc.

For Question #2 (designing a wall system for all climate zones), we used **WUFI-2D** for the analysis. WUFI-2D expands the capability of WUFI-Pro to a two-dimensional analysis. A one-dimensional analysis cannot accurately calculate the impact of thermal bridging resulting from complicated geometries, such as metal framing within a wall assembly. Compared to WUFI-Pro, the inputs for WUFI-2D are considerably more complex, and the computational time is also significantly increased. This study is truly unique because it the first ever that includes these 2-dimensional effects (heat flow, vapor flows, airflows, liquid transport), but also because it used a post processing software to calculate the risk for mold growth (Standard ASHRAE 160 [6]) and corrosion damage (ISO 9223 [7]).

Hygrothermal Material Property Testing

For this study, we focused on mineral wool insulation manufactured by Owens Corning LLC, see **Figure 5**. To evaluate the moisture performance of Thermafiber® RainBarrier® exterior continuous insulation, the material was put through rigorous laboratory testing (ASTM E96 [3], ASTM C1498 [4]) and a full set of hygrothermal material properties were developed at the Oak Ridge National Laboratory. The properties measured were water vapor permeance, sorption isotherm, liquid uptake, saturation moisture content and thermal conductivity. Functional dependencies measurements on either temperature or relative humidity were also conducted.

FIGURE 5 — Owens Corning® Thermafiber® RainBarrier® is permeable to water vapor, yet hygrophobic to liquid water as seen by the water beading on top.

The **water vapor permeance** measurements were made according to ASTM E 96, Standard Test Methods for Water Vapor Transmission of Materials. Both wet and dry cup measurements were performed with different specimens. In **Table 5** the measured water vapor permeance is shown as a function of both dry and wet cup conditions. This information is important to input into the simulation analysis to capture the real performance of the walls.

TABLE 5 — Water Vapor Permeance Testing Thermafiber® RainBarrier®.

	WATER VAPOR PERMEANCE (ASTM E96)	
	DRY CUP AMBIENT: 50% RH CUP: 0% RH	WET CUP AMBIENT: 50% RH CUP: 100% RH
RainBarrier® (1")	95.9 perms	127.8 perms

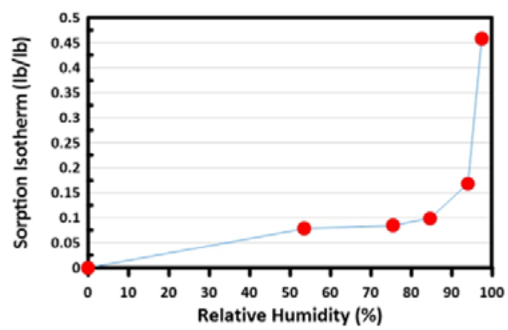


FIGURE 6 — Hygroscopic Sorption of Thermafiber® RainBarrier®.

Sorption isotherm measurements were conducted using ASTM C 1498, Standard Test Method for Hygroscopic Sorption Isotherms of Building Materials. Triplicate specimens consisting of 15 grams each of material cut into small pieces were used, starting with the lowest RH, and after equilibrium was reached, the specimens were transferred to the next higher RH until measurements had been made over the range of relative humidity. The moisture content reported is the average of the three specimens. **Figure 6** shows the sorption isotherm as a function of relative humidity displaying a low affinity for water.

Thermal conductivity measurements were taken using a heat flow meter apparatus according to ASTM C 518 [8]. The apparatus used has hot and cold plates that are 12 inches square with 3-inch square heat flux transducers in each plate. Tests were performed on single boards and on stacks of two, three, or four boards. The thermal conductivity of Thermafiber® RainBarrier® is presented in **Table 6** for mean temperatures of 37.4°F, 75°F and 95°F.

TABLE 6 — Thermal Conductivity of Thermafiber® RainBarrier®.

k (W/m/K)	PLATE TEMPERATURES (UPPER/LOWER) [MEAN]		
	k, -9°C / 15°C [3°C, 37.4°F]	k, 12.8°C / 35°C [23.9°C, 75°F]	k, 23°C / 48°C [35.5°C, 95.9°F]
RainBarrier®	0.03158	0.03445	0.03608

Liquid diffusivity measurements are not covered by an ASTM standard. Specimens were 3 inches square, and the edges were sealed with epoxy. The finished face of the specimen was then brought into contact with a liquid water surface. The specimens were periodically removed from the water tank and weighed. A plot of mass gain versus the square root of the exposure time gives an initial linear portion that is analyzed to calculate the liquid diffusivity. To measure free saturation moisture content, the sample was submerged for 28 days, then the excess water was allowed to run off for 10 minutes before measuring. (**Table 7**).

TABLE 7 — Liquid water uptake and free saturation moisture content.

	LIQUID WATER UPTAKE ($kg/m^2, s^{0.5}$)		FREE SATURATION (WT. %)
MATERIAL NAME	A (24H)	A (4H)	
RainBarrier®	8.9E-04	3.0E-03	442.3

STUDY #1 – DRYING CAPABILITY OF PERMEABLE MINERAL WOOL

To understand the moisture performance of vapor permeable versus vapor impermeable exterior continuous insulations, an analysis was conducted on a brick clad enclosure wall system as shown in **Figure 7**. For the vapor impermeable insulation case a foil faced polyisocyanurate board (0.03 perms) was used, an expanded polystyrene (EPS) board was used for the semi-permeable case (5 perm) and Owens Corning Thermafiber® RainBarrier® mineral wool board (~100 perm) was used for the vapor permeable case. WUFI-1D version 6.5 was used for the parametric analysis. The material properties measured at ORNL were used for Thermafiber® RainBarrier® material properties, while Building Science Corporation [11] data was used for the Polyisocyanurate material properties, and the EPS measurements performed at NRCC [12]. The same R-value was used for all three insulation cases.

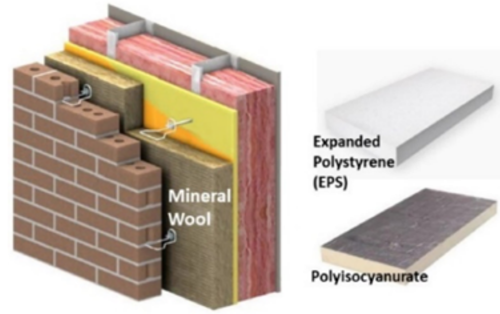


FIGURE 7 — Wall assembly study using 3 Types of CI.

Three geographic locations were selected for this analysis; Minneapolis, Seattle and Tampa, and the Moisture Reference Years as per the ASHRAE TRP 1325 [13] were used. Interior loads as found in occupied residences, with 2 adults and 2 children were used in the analysis. The interior conditions were calibrated based on extensive measurements conducted by HUD [14]. A 1-perm vapor retarder sheet (Class II) was used for the Minneapolis and Seattle locations, while no vapor retarder was used for Tampa. An 8 Perm interior vapor permeance paint (Class III) was used for all three locations. A 60 perm WRB applied to the exterior gypsum was used for all three cases.

The objective of this analysis was to quantify the moisture performance of a wall using three different exterior continuous insulation, starting with high construction moisture in the exterior grade gypsum board. High initial construction is typically found when construction materials are left unprotected in ambient conditions.

Results

The moisture performance of the exterior gypsum board is shown in **Figure 8** for all three exterior insulation systems and climates. The excellent drying performance of the wall using Thermafiber® RainBarrier® as the exterior continuous insulation is clearly shown, with the biggest differences seen in Minneapolis and Seattle. The brick wall assembly using Thermafiber® RainBarrier® mineral wool dried the fastest in both these climate zones, while the wall using the foil faced polyisocyanurate insulation dried the slowest. The wall with EPS showed drying times between the mineral wool and polyisocyanurate walls.

Thermafiber® RainBarrier® Mineral Wool CI allows walls to dry faster than less permeable insulations.

Table 8 shows the drying times required for the exterior grade gypsum to reach two critical moisture contents, 5 lb/ft^3 and 10 lb/ft^3, for each wall in each city. In Minneapolis the wall using MW CI required 675 hrs for the gypsum to dry to the 10 lb/ft^3 level and 1214 hrs to dry to 5 lb/ft^3, while the EPS wall required 7,068 hrs and 15,000 hrs respectively, roughly 10.5 times longer. The wall using foil faced polyisocyanurate never did dry to either of these levels. A similar story is seen in Seattle.

Note that for the Tampa case, the foil faced polyisocyanurate CI did perform well, allowing the exterior gypsum to dry to both the 5 lb/ft^3 and 10 lb/ft^3 levels. This is to be expected since Tampa is a hot, humid climate and the highest concentration of water vapor would be on the exterior side of the wall throughout most the year. Thus, using a 'vapor control layer' strategy with the impermeable foil faced polyisocyanurate on the exterior would be an appropriate vapor control strategy, i.e., retard vapor flow from the exterior and allow drying to the interior.

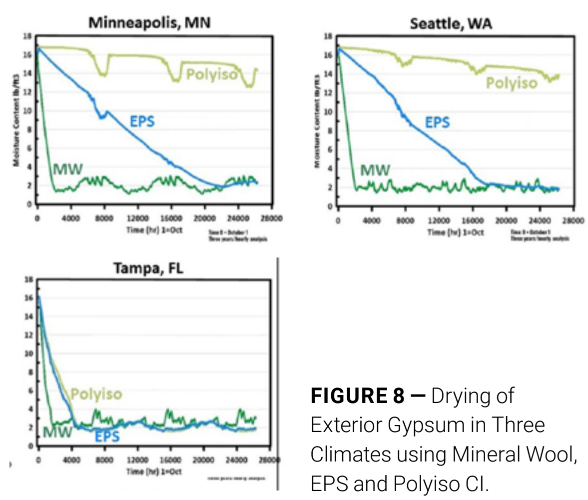


FIGURE 8 — Drying of Exterior Gypsum in Three Climates using Mineral Wool, EPS and Polyiso CI.

TABLE 8 — Drying Times of Exterior Gypsum using Mineral Wool, EPS and Polyiso CI.

GYPSUM MOISTURE CONTENT	MINNEAPOLIS			SEATTLE			TAMPA		
	MW CI	EPS CI	FOIL FACED POLYISO CI	MW CI	EPS CI	FOIL FACED POLYISO CI	MW CI	EPS CI	FOIL FACED POLYISO CI
10 lb/ft^3	675 hours	7,068 hours	Did not dry to this level in 3 years	846 hours	7,461 hours	Did not dry to this level in 3 years	503 hours	1,262 hours	1,375 hours
5 lb/ft^3	1,214 hours	15,000 hours	Did not dry to this level in 3 years	1,516 hours	14,128 hours	Did not dry to this level in 3 years	1,095 hours	1,095 hours	3,678 hours

However, even in Tampa, the wall with Thermafiber® RainBarrier® mineral wool outperformed both the foil faced polyisocyanurate and EPS walls. **This demonstrates the robustness of using vapor permeable mineral wool and the 'flow through' vapor control strategy**. These walls work equally well in cold/dry, hot/humid, and even marine climate zones. We will further demonstrate the design flexibility of this approach in Study #2.

STUDY #2 – OPTIMAL WALL DESIGNS ACROSS US CLIMATE ZONES

The objective of Study #2 was to expand on the findings in Study #1 and evaluate the vapor control strategies utilizing Thermafiber® RainBarrier® mineral wool exterior insulation across nine US climate zones. A full WUFI-2D hygrothermal analysis was performed as shown in **Table 9**. Six weather resistive membranes with different permeabilities were analyzed along with two vapor retarder strategies using Class II and Class III vapor retarders. The study also evaluated both 2x4 and 2x6 walls, as well as two exterior cladding systems (brick and metal panels). MW exterior insulation R-values were chosen to meet or exceed the 2018 IECC code (**Table 10**). This extensive 2-D hygrothermal study included almost 1000 simulation cases.

Nine locations were selected for the study to represent the major climate zones across the US (**Figure 9**). For the nine locations, Moisture Reference Years (MRY) were deployed. A 1% water penetration on the exterior surface of the WRB was used for simulations. The study also included two interior moisture loads, Normal and High, to understand the impact of different occupancy types on the moisture performance. For the interior moisture loads, the hourly interior relative humidity's were calculated using the following moisture production guidelines and rates:

- Use of the EN ISO 15026 ASHRAE Handbook of HVAC Applications 2011 Chapter 3.2, 74-78ºF Winter and 72-75ºF Summer
- 17 cfm/person, Max RH = 60%
- Moisture Production (MP) = 70g/h/person, 25% plants
    - **Normal loads** (5 people/100 m^2 = 2.8 g/m^3)
    - **High loads** (10 people/100 m^2 = 5.6 g/m^3)

Figure 10 shows the outdoor and indoor temperatures and relative humidity conditions for Minneapolis for normal loads. The interior conditions are highly variable depicting full transient conditions.

The 2-dimensional analysis allowed a unique look at the transport of heat and moisture around a steel stud. A cross sectional analysis with the control volumes used in the study is shown in **Figure 11**. In a 1-dimensional analysis, the total number of control volumes for the partial differential equations for mass and energy conservation is typically between 50 to 60. In all the analysis performed in this study 2135 control volumes were used. All the analysis performed used the ASHRAE SPC 160 [6] standard for guidance in setting up the analysis. For both the vapor retarder (0.5 perm) and no vapor retarder cases an 8-perm painted gypsum coating was used.

Figure 12 shows an example of the impact of using a 2-D analysis through a cross section of the wall. The presence of the steel studs is clearly seen in both the spatial temperature and relative humidity conditions. Here it is important to notice the impact of thermal bridging and thermal capacity of the steel on the overall performance of the enclosure wall.

Once a specific wall construction was analyzed for a given location and interior moisture load (normal or high), the 2-year temperature and relative humidity simulations were postprocessed to develop maximum mold potential. The Hannu Viitanen mold growth index was deployed as the metric for predicting the risk for mold growth. This approach is based on decades of lab testing and field verification. The Mold Growth Index was first proposed by Viitanen and Ritschkoff (1991), which was used to quantify the amount of mold growth that took place in laboratory tests under controlled temperature and humidity conditions.

TABLE 9 — Parametric Analysis of Wall Assemblies with Thermafiber® RainBarrier® Mineral Wool Insulation.

CLADDING	EXTERIOR CONTINUOUS INSULATION	FRAMING OPTIONS	VAPOR RETARDER OPTIONS	WEATHER RESISTIVE MEMBRANES
Brick	Thermafiber® RainBarrier® mineral wool	2x4 Steel, 2x6 Steel,	Class II (0.5 perms) Class III (8 perms)	0.14, 1, 5, 10, 30, and 120 perms
Metal Panel	Thermafiber® RainBarrier® mineral wool	2x4 Steel, 2x6 Steel,	Class II (0.5 perms) Class III (8 perms)	0.14, 1, 5, 10, 30, and 120 perms

TABLE 10 — US Climate Zones, Code Requirements and Study R-values.

CITY	STATE	IECC CLIMATE ZONE	2018 IECC MINUMUM INSULATION REQUIREMENT FOR METAL FRAMED WALL	R-VALUES OF THERMAFIBER® RAINBARRIER® USED IN STUDY
Miami	FL	1A	R13 + R-5ci	R-6.5ci
New Orleans	LA	2A	R13 + R-5ci (Group other) R13 + R-7.5ci (Group R)	R-6.5ci
Atlanta	GA	3A	R13 + R-7.5ci	R-8.7ci
San Francisco	CA	3C	R13 + R-7.5ci	R-8.7ci
Baltimore	MD	4A	R13 + R-7.5ci	R-8.7ci
Seattle	WA	4C	R13 + R-7.5ci	R-8.7ci
Portland	OR	4C	R13 + R-7.5ci	R-8.7ci
Chicago	IL	5A	R13 + R-7.5ci	R-8.7ci
Minneapolis	MN	6A	R13 + R-7.5ci	R-8.7ci

FIGURE 9 — IECC Climate Zone Map and Cities Analyzed in Study.

FIGURE 10 — Example of Indoor/Outdoor Temp & RH for Minneapolis (full year).

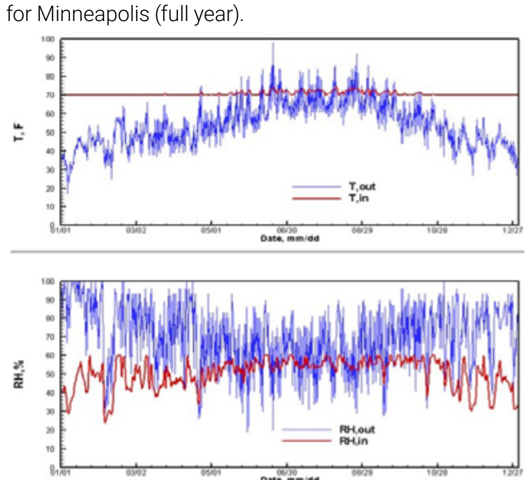


FIGURE 11 — Example Wall Profile and Control Volumes (finite elements) for WUFI Analysis.

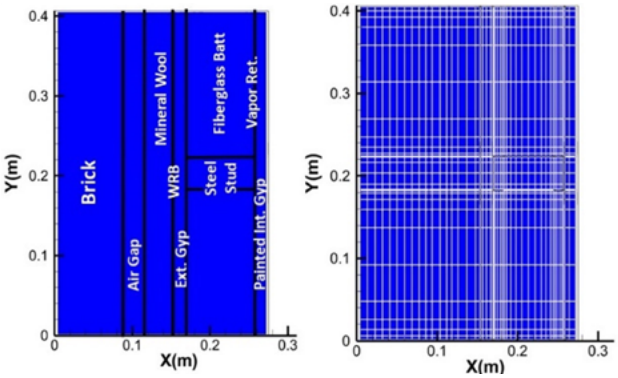
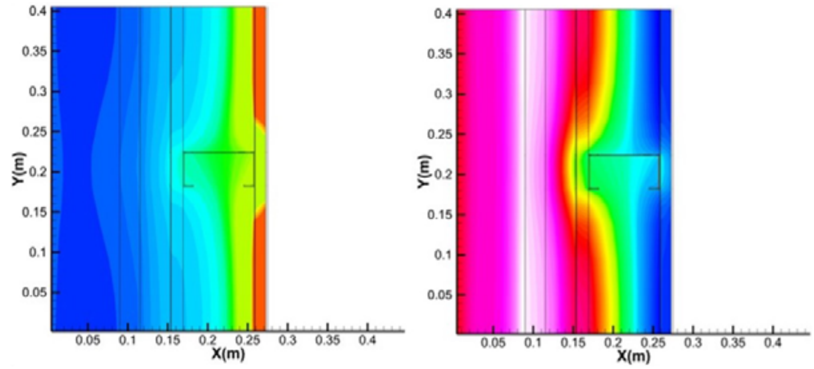


FIGURE 12 — Example of Spatial Temperature (left) and Relative Humidity (right) profiles.



Initially they were steady state conditions but evolved into transient testing. The mold growth index assigns an ordinal number between 0 (no growth) and 6 (very heavy and tight growth). The Viitanen model can calculate the mold growth index from outputs of hygrothermal simulations and incorporates time, surface temperature, surface relative humidity, and the material sensitivity class. **Table 11** provides additional descriptions for mold growth index.

TABLE 11 — Mold Growth Index as per Hannu Viitanen

INDEX	DESCRIPTION OF THE MOLD GROWTH RATE
0	No growth
1	Small amounts of mold on surface (microscope), initial stages of local growth
2	Several local mold growth colonies on surface (microscope)
3	Visual findings of mold on surface, <10% coverage of <50% coverage of mold (microscope)
4	Visual findings of mold on surface, 10-50% coverage of >50% coverage of mold (microscope)
5	Plenty of growth on surface >50% coverage (visual)
6	Heavy and tight growth, coverage about 100%

The WUFI® Mold Index VTT add-on was developed in collaboration between the Finnish research institute VTT and Fraunhofer IBP. The Mold Index (MI) was developed, which indicates the intensity of growth using the easy-to-understand six-point scale. It is also takes into account that mold growth can decrease during longer dry spell periods. The WUFI® Mold Index VTT postprocessor now contains the mold growth criteria according to the ASHRAE standard 160. ASHRAE Standard 160 requires that the mold growth index, calculated from hygrothermal simulations, be less than 3 (the threshold for visible mold growth).

In addition to the Mold Index, the Time of Wetness (TOW) was also post-processed for each control volume in the enclosure. TOW is the accumulated time in hours in a year when the temperature is above freezing, and the relative humidity is above 80% (out of a possible 8760 hours in a year). To more easily understand the durability performance of the walls analyzed in this study, a color chart was developed to map the numerical Mold Index and TOW as shown in **Figure 13**.

FIGURE 13 — Color scale for time of wetness and mold index.

Assessment Criteria

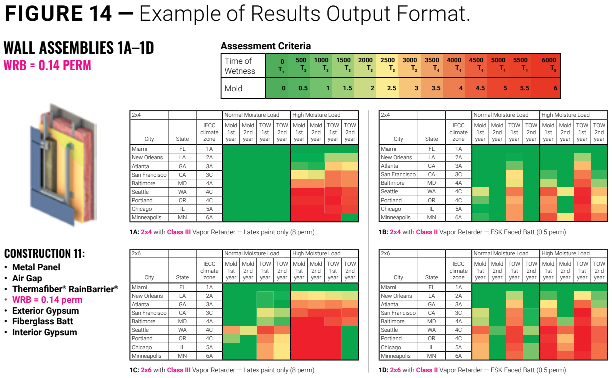
Time of Wetness	0 T_1	500 T_2	1000 T_3	1500 T_3	2000 T_3	2500 T_3	3000 T_3	3500 T_4	4000 T_4	4500 T_4	5000 T_4	5500 T_4	6000 T_5
Mold	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6

A parametric study of this breadth and depth is unique and possibly the first of its kind.

RESULTS FORMAT

The results of the full parametric study are shown in the Appendix as Wall Assemblies 1-12. All 12 Assemblies utilize Thermafiber® RainBarrier® mineral wool as the exterior continuous insulation. Assemblies 1-6 use Metal Panel as the cladding and Assemblies 7-12 use Brick. Within each cladding type, there are six different WRB permeabilities. Assembly 1 has a WRB = 0.14 perm, Assembly #2 WRB = 1 perm, and so on, up to Assembly #6 with a WRB = 120 perm. The WRB permeability series repeats for the Brick claddings in Assemblies 7-12.

FIGURE 14 — Example of Results Output Format.



Within each Assembly there are four 'sub-constructions' noted as A, B, C and D. **Figure 14** shows an example for Wall Assembly 1. Assembly 1A (upper left) uses Thermafiber® RainBarrier®, Metal Cladding and WRB = 0.14 perm in a 2x4 wall with no additional vapor retarder other than the Class III, 8-perm latex paint on the drywall. The Year 1 and Year 2 Mold Index and Time of Wetting (TOW) output from the WUFI-2D analysis are shown for all nine cities using both Normal and High interior moisture loads. Assembly 1B (upper right) is identical to 1A, except an FSK faced fiberglass batt replaces the unfaced batt used in 1A. The FSK provides a Class II vapor retarder (0.5 perm). Assemblies 1C & 1D are the same as Assemblies 1A & 1B respectively, except they are for 2x6 walls. Assemblies 7-12 repeat the same analysis, except using Brick as the exterior cladding. **Note each Wall Assembly output figure is a summary of 72 individual WUFI-2D simulations, or a total of 864 runs for the 12 Assemblies.**

RESULTS DISCUSSION

Summary

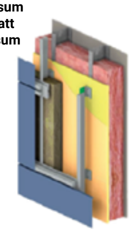
Like the findings in Study #1, the nine-city parametric Study #2 demonstrates the benefit of using vapor permeable Thermafiber® RainBarrier® mineral wool as the exterior continuous insulation. Pairing vapor permeable Thermafiber® RainBarrier® mineral wool with a vapor permeable WRB and a Class III vapor retarder results in low TOW and Mold Index in all nine cities/climate zones. This design allows water vapor to dry to both sides of the wall assembly. The study also demonstrated the robustness of this assembly as it continued to show excellent TOW and Mold Index performance even when the interior moisture loads were increased.

Metal Panel and Vapor Impermeable WRB

Before we discuss the performance of the vapor permeable WRB and Thermafiber® RainBarrier® mineral wool assembly, let's review the performance of the assembly using a vapor impermeable WRB which is shown in the Appendix as Wall Assemblies 1A–1D. This features a Metal Panel cladding, Thermafiber® RainBarrier® CI and a vapor impermeable 0.14 perm WRB. Note the strict definition of 'impermeable is <0.1 perm, so technically this WRB does fall in the category of 'semi-impermeable (0.1 to <1.0 perms), but regardless of the classification, it has a very low water vapor transmission (although higher than the 0.03 perm foil facing on the polyisocyanurate foam in Study #1).

FIGURE 15 — 2x4 wall with WRB = 0.14 perms and Class III Vapor Retarder.

CONSTRUCTION 1:
- Metal Panel
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 0.14 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum



2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

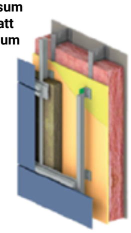
1A: 2x4 with **Class III** Vapor Retarder — Latex paint only (8 perm)

Figure 15 shows the 2x4 wall version of this assembly using a Class III, 8 perm interior vapor retarder (latex paint). Under Normal interior moisture loads, the WUFI analysis does not show any TOW or Mold concerns throughout the nine climate zones (all green). The insulating effect of the exterior CI keeps the wall cavity warm, helping to maintain humidity at acceptable levels. However, when the moisture load is increased to High, the TOW and Mold risks become elevated (red & orange), especially in colder climate zones. The amount of water vapor diffusing into the wall is increased, and since the amount of drying to the outside is restricted, the humidity levels rise in the wall cavity, which in turn elevates the TOW and Mold risk. This is similar to what we saw in Study #1 with the slow drying capability of the wall with foil faced polyisocyanurate exterior insulation.

A logical approach to addressing the higher interior moisture load would be to add a Class II vapor retarder (0.5 perm FSK facing) toward the interior side of the wall assembly to retard the water vapor flow. **Figure 16** shows the results of adding the Class II vapor retarder to the 2x4 wall. Clearly, the Class II vapor retarder does improve the performance of the wall assembly under High interior moisture loads. While there is still elevated TOW and Mold in Year 1, there is improvement in Year 2 as the wall continues to dry. Interestingly, the wall now shows poorer moisture performance under Normal interior moisture loads (elevated TOW in Year 1). Adding the lower perm vapor retarder reduces the flow of water vapor into the wall cavity but also has the unintended consequence of reducing the drying of 'construction moisture' to the interior. While this moisture was able to dry quickly with the Class III vapor retarder, it dries out slower with the Class II vapor retarder. This is an example of the statement made earlier in the Theory of Vapor Control section, "sometimes the best strategies to keep water vapor out under one scenario can trap water vapor under another scenario."

FIGURE 16 — 2x4 wall with WRB = 0.14 perms and Class II Vapor Retarder.

CONSTRUCTION 1:
- Metal Panel
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 0.14 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum



2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

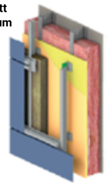
1B: 2x4 with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

While the story is similar for **2x6 wall assemblies** (Assemblies 1C & 1D), these walls do show elevated TOW and Mold index even under **normal** interior moisture loads compared to the 2x4 walls. This is to be expected since the higher level of cavity insulation with the 2x6 wall reduces the temperature of the exterior gypsum, thus increasing the relative humidity levels at that interface. As was seen with the 2x4 wall, subjecting the 2x6 wall to **high** interior moisture loads also significantly elevates the TOW and Mold risks (**Figure 17**). Adding a Class II vapor retarder (**Figure 18**) does help retard the High interior moisture loads, but it also has the unintended consequence of reducing the drying of the 'construction moisture', even under Normal moisture loads (**Figure 18**).

Metal Panel and Vapor Permeable WRB

FIGURE 17 — 2x6 wall with WRB = 0.14 perms and Class III Vapor Retarder.

CONSTRUCTION 1:
- Metal Panel
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 0.14 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum

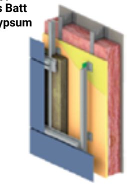


2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

1C: 2x6 with **Class III** Vapor Retarder — Latex paint only (8 perm)

FIGURE 18 — 2x6 wall with WRB = 0.14 perms and Class II Vapor Retarder.

CONSTRUCTION 1:
- Metal Panel
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 0.14 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum



2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

1D: 2x6 with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

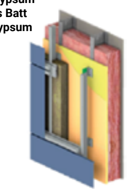
Examining the performance of Wall Assemblies 2 through 6, we can clearly see the improving moisture performance of the wall assemblies as the permeability of the WRB increases, from 1 perm up to 120 perms. The combination of a more permeable WRB with the already high permeability of the Thermafiber® RainBarrier® mineral wool, allows more drying to the outside which lowers both the Time of Wetting (TOW) and the potential for Mold.

Figures 19 and **20** show the performance of Wall Assembly 5 with Metal Panel cladding, Thermafiber® RainBarrier® mineral wool and a WRB = 30 perm. **Figure 19** is the 2x4 wall version of this wall with a Class III vapor retarder, and **Figure 20** is the 2x6 and Class III version. Under both Normal and High interior moisture loads, the 2x4 and 2x6 walls both show excellent performance across all nine climate zones. This is a very robust design given its ability to dry to either side of the wall. Note there is a very slightly elevated TOW in New Orleans. Given the hot/humid conditions in New Orleans, using a WRB with a lower permeability on the exterior may be appropriate for this climate zone. In fact, reviewing Wall Assembly (WRB = 10 perm) does improve the TOW performance in New Orleans.

Figure 21 shows the performance of the Metal Panel cladding, Thermafiber® RainBarrier® mineral wool and a WRB = 30 perm, but with a Class II (0.5 perm) vapor retarder. A Class II vapor retarder is not allowed by code (Table 3) in Climate Zones 1 or 2 and the WUFI analysis confirms the poor performance of this vapor retarder approach in those climates. In Climate Zones 3 through 6, the wall does perform well under both Normal and High interior moisture loads. However, unless there is a specific moisture condition that warrants a more aggressive vapor retarder strategy (e.g., very high interior humidity's), using the Class III vapor retarder strategy still provides a more robust moisture management strategy as there is no concern when transitioning from Climate Zone 3 to Climate Zone 2, as there would be when using a Class II vapor retarder.

FIGURE 19 — 2x4 wall with WRB = 30 perms and Class III Vapor Retarder.

CONSTRUCTION 5:
- Metal Panel
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 30 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum

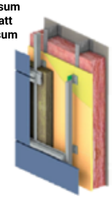


2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

5A: 2x4 with **Class III** Vapor Retarder — Latex paint only (8 perm)

FIGURE 20 — 2x6 wall with WRB = 30 perms and Class III Vapor Retarder.

CONSTRUCTION 5:
- Metal Panel
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 30 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum

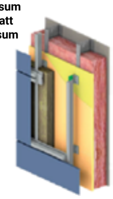


2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

5C: 2x6 with **Class III** Vapor Retarder - Latex paint only (8 perm)

FIGURE 21 — 2x4 wall with WRB = 30 perms and Class II Vapor Retarder.

CONSTRUCTION 5:
- Metal Panel
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 30 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum



2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

5B: 2x4 with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

Brick Cladding Analysis

The Brick cladding (Wall Assemblies 7 through 12) analysis shows similar results to the Metal Panel analysis. Increasing the permeability of the WRB in combination with the Thermafiber® RainBarrier® mineral wool exterior insulation improves the overall moisture performance of the wall assembly. However, the WUFI analysis with Brick does show some differences from the Metal Panel clad walls due to the moisture properties of Brick (retaining and releasing moisture).

Figure 22 shows the performance of an impermeable WRB (0.14 perm) and a Class III vapor retarder (8 perm latex paint). Like the Metal Panel analysis (**Figure 15**), this wall performs well under Normal interior moisture loads. However, when the interior moisture loads are increased, the analysis shows significant Time of Wetting (TOW) and Mold risks. **Figure 23** shows the impact of adding a Class II vapor retarder (FSK facer added to the fiberglass cavity insulation). Like the Metal Panel example in **Figure 16**, the addition of the Class II vapor retarder improves the moisture performance under High moisture loads but has the unintended consequence of elevating the TOW and Mold risk Normal moisture load scenarios.

FIGURE 22 — 2x4 wall with WRB = 0.14 perms and Class III Vapor Retarder.

CONSTRUCTION 7:
- Brick
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 0.14 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

7A: 2x4 with **Class III** Vapor Retarder — Latex paint only (8 perm)

FIGURE 23 — 2x4 wall with WRB = 0.14 perms and Class II Vapor Retarder.

CONSTRUCTION 7:
- Brick
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 0.14 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum

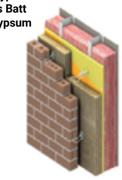
2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

7B: 2x4 with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

Figure 24 shows a better approach of using a permeable WRB (30 perm) and a Class III vapor retarder (8 perm latex paint). Like the Metal Panel analysis (**Figure 19**), the moisture performance of this wall assembly is excellent across all nine climate zones under Normal moisture loads. Under High moisture loads, like with Metal Panels, there is a slight elevation in TOW for New Orleans with Brick. Interestingly, unlike Metal Panels, lowering the permeability of the WRB to 5 or 10 perms (Wall Assemblies 9 and 10) did not have a significant impact on the New Orleans analysis. Fortunately, the WUFI analysis shows no corresponding elevated Mold risk for New Orleans.

FIGURE 24 — 2x4 wall with WRB = 30 perms and Class III Vapor Retarder.

CONSTRUCTION 11:
- Brick
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 30 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum



2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

11A: 2x4 with **Class III** Vapor Retarder — Latex paint only (8 perm)

FIGURE 25 — 2x4 wall with WRB = 120 perms and Class III Vapor Retarder.

CONSTRUCTION 12:
- Brick
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 120 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

12A: 2x4 with **Class III** Vapor Retarder — Latex paint only (8 perm)

The Brick analysis also shows a higher TOW in the Marine climate zone of Seattle. This was not seen with Metal Panels. Increasing the permeability of the WRB to 120 perms (**Figure 25**) improves the moisture performance across all nine climate zones (again with the caveat of New Orleans under High loads). This would suggest the optimal design for Brick cladding, is a WRB with a permeability between 30 and 120 perms. Note the permeability of the WRB in Study #1 was 60 perms with Brick Cladding, and this showed excellent drying in all three climate zones – Tampa, Seattle, and Minneapolis.

CONCLUSIONS

An extensive hygrothermal analysis was performed on above grade walls using permeable Thermafiber® RainBarrier® mineral wool as the exterior continuous insulation with both Metal and Brick Cladding systems. Overall, the study demonstrated that vapor permeable Thermafiber® RainBarrier® exterior insulation lowers the risk of moisture problems compared to other less permeable insulations. Specific findings from the study:

1. Walls using permeable Thermafiber® RainBarrier® mineral wool continuous insulation had **faster 'dry out times'** of initial construction moisture than foil-faced polyisocyanurate and EPS foam insulations.
2. A single wall design using Thermafiber® RainBarrier® mineral wool continuous insulation, a permeable WRB and a Class III vapor retarder **demonstrated exceptional moisture performance across all climate zones** (Florida to Minnesota) and under varying interior moisture loads (normal and high).

REFERENCES

[1] Architecture 2030. (n.d.). Meeting the 2030 challenge. https://www.architecture2030.org/2030_challenges/2030-challenge/

[2] Oak Ridge National Laboratory https://www.ornl.gov/

[3] ASTM E96 Standard Test Methods for Water Vapor Transmission of Materials

[4] ASTM C1498 Standard Test Method for Hygroscopic Sorption Isotherms of Building Materials

[5] Fraunhofer IBP. (2024). WUFI (EN). WUFI. https://wufi.de/en/software/what-is-wufi/

[6] Standard ASHRAE 160 Criteria for Moisture-Control Design Analysis in Buildings

[7] ISO 9223 Corrosion of metals and alloys – Corrosivity of atmospheres – Classification, determination and estimation

[8] ASTM C 518 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

[9] Piñon, J. P., Davidovic, D., Burnette, E. F. P., & Srebric, J. (2004). THE AIRFLOW CHARACTERISTICS OF VENTILATED CAVITIES IN SCREEN-TYPE ENCLOSURE WALL SYSTEMS (RP-1091). ASHRAE.

[10] Derome, D., Karagiozis, A., & Carmeliet, J. (2010). THE NATURE, SIGNIFICANCE AND CONTROL OF SOLAR-DRIVEN DIFFUSION IN WALL SYSTEM-SYNTHESIS OF RESEARCH PROJECT RP-1235. ASHRAE.

[11] Building Science Corporation https://buildingscience.com/

[12] Mukhopadhyaya, P., Bomberg, M. T., Kumaran, M. K., Drouin, M., J. C., L., Van Reenen, D., & Normandin, N. (2002). Long-term thermal resistance of polyisocyanurate foam insulation with impermeable facers. NRCC National Research Council Canada.

[13] Salonvaara, M. (2011). ENVIRONMENTAL WEATHER LOADS FOR HYGROTHERMAL ANALYSIS AND DESIGN OF BUILDINGS. ASHRAE.

[14] U.S. Department of Housing and Urban Development https://www.hud.gov/

APPENDIX

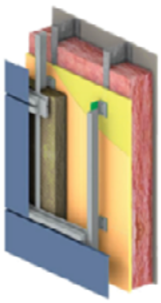
Full Parametric Results

WALL ASSEMBLIES 1A–1D

WRB = 0.14 PERM

Assessment Criteria

Time of Wetness	0 T_1	500 T_2	1000 T_3	1500 T_3	2000 T_3	2500 T_3	3000 T_3	3500 T_4	4000 T_4	4500 T_4	5000 T_4	5500 T_4	6000 T_5
Mold	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6



CONSTRUCTION 11:

- Metal Panel
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 0.14 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

1A: 2x4 with Class III Vapor Retarder — Latex paint only (8 perm)

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

1B: 2x4 with Class II Vapor Retarder — FSK Faced Batt (0.5 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

1C: 2x6 with Class III Vapor Retarder — Latex paint only (8 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

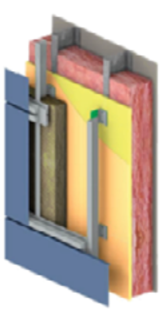
1D: 2x6 with Class II Vapor Retarder — FSK Faced Batt (0.5 perm)

WALL ASSEMBLIES 2A–2D

WRB = 1.0 PERM

Assessment Criteria

Time of Wetness	0 T_1	500 T_2	1000 T_3	1500 T_3	2000 T_3	2500 T_3	3000 T_3	3500 T_4	4000 T_4	4500 T_4	5000 T_4	5500 T_4	6000 T_5
Mold	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6



CONSTRUCTION 12:

- Metal Panel
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 1.0 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

2A: 2x4 with Class III Vapor Retarder — Latex paint only (8 perm)

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

2B: 2x4 with Class II Vapor Retarder — FSK Faced Batt (0.5 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

2C: 2x6 with Class III Vapor Retarder — Latex paint only (8 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

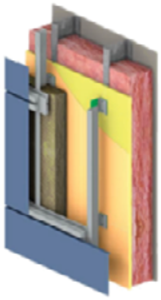
2D: 2x6 with Class II Vapor Retarder — FSK Faced Batt (0.5 perm)

WALL ASSEMBLIES 3A–3D

WRB = 5 PERM

Assessment Criteria

Time of Wetness	0 T_1	500 T_2	1000 T_3	1500 T_3	2000 T_3	2500 T_3	3000 T_3	3500 T_4	4000 T_4	4500 T_4	5000 T_4	5500 T_4	6000 T_5
Mold	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6



2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

3A: **2x4** with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

3B: **2x4** with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

CONSTRUCTION 3:

- **Metal Panel**
- **Air Gap**
- **Thermafiber® RainBarrier®**
- **WRB = 5 perm**
- **Exterior Gypsum**
- **Fiberglass Batt**
- **Interior Gypsum**

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

3C: **2x6** with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

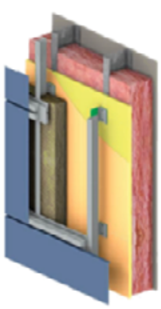
3D: **2x6** with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

WALL ASSEMBLIES 4A–4D

WRB = 10 PERM

Assessment Criteria

Time of Wetness	0 T_1	500 T_2	1000 T_3	1500 T_3	2000 T_3	2500 T_3	3000 T_3	3500 T_4	4000 T_4	4500 T_4	5000 T_4	5500 T_4	6000 T_5
Mold	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6



2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

4A: **2x4** with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

4B: **2x4** with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

CONSTRUCTION 4:

- **Metal Panel**
- **Air Gap**
- **Thermafiber® RainBarrier®**
- **WRB = 10 perm**
- **Exterior Gypsum**
- **Fiberglass Batt**
- **Interior Gypsum**

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

4C: **2x6** with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

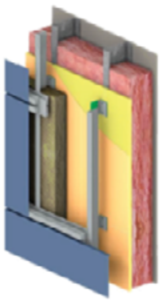
4D: **2x6** with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

WALL ASSEMBLIES 5A–5D

WRB = 30 PERM

Assessment Criteria

Time of Wetness	0 T_1	500 T_2	1000 T_3	1500 T_3	2000 T_3	2500 T_3	3000 T_3	3500 T_4	4000 T_4	4500 T_4	5000 T_4	5500 T_4	6000 T_5
Mold	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6



CONSTRUCTION 5:

- Metal Panel
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 30 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

5A: 2x4 with Class III Vapor Retarder — Latex paint only (8 perm)

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

5B: 2x4 with Class II Vapor Retarder — FSK Faced Batt (0.5 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

5C: 2x6 with Class III Vapor Retarder — Latex paint only (8 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

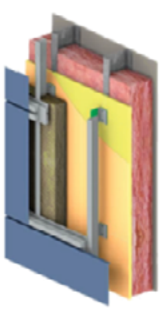
5D: 2x6 with Class II Vapor Retarder — FSK Faced Batt (0.5 perm)

WALL ASSEMBLIES 6A–6D

WRB = 120 PERM

Assessment Criteria

Time of Wetness	0 T_1	500 T_2	1000 T_3	1500 T_3	2000 T_3	2500 T_3	3000 T_3	3500 T_4	4000 T_4	4500 T_4	5000 T_4	5500 T_4	6000 T_5
Mold	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6



CONSTRUCTION 6:

- Metal Panel
- Air Gap
- Thermafiber® RainBarrier®
- WRB = 120 perm
- Exterior Gypsum
- Fiberglass Batt
- Interior Gypsum

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

6A: 2x4 with Class III Vapor Retarder — Latex paint only (8 perm)

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

6B: 2x4 with Class II Vapor Retarder — FSK Faced Batt (0.5 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

6C: 2x6 with Class III Vapor Retarder — Latex paint only (8 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

6D: 2x6 with Class II Vapor Retarder — FSK Faced Batt (0.5 perm)

WALL ASSEMBLIES 7A–7D

WRB = 0.14 PERM

Assessment Criteria

Time of Wetness	0 T_1	500 T_2	1000 T_3	1500 T_3	2000 T_3	2500 T_3	3000 T_3	3500 T_4	4000 T_4	4500 T_4	5000 T_4	5500 T_4	6000 T_5
Mold	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

7A: **2x4** with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

7B: **2x4** with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

CONSTRUCTION 7:

- **Brick**
- **Air Gap**
- **Thermafiber® RainBarrier®**
- **WRB = 0.14 perm**
- **Exterior Gypsum**
- **Fiberglass Batt**
- **Interior Gypsum**

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

7C: **2x6** with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

7D: **2x6** with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

WALL ASSEMBLIES 8A–8D

WRB = 1.0 PERM

Assessment Criteria

Time of Wetness	0 T_1	500 T_2	1000 T_3	1500 T_3	2000 T_3	2500 T_3	3000 T_3	3500 T_4	4000 T_4	4500 T_4	5000 T_4	5500 T_4	6000 T_5
Mold	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

8A: **2x4** with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

8B: **2x4** with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

CONSTRUCTION 8:

- **Brick**
- **Air Gap**
- **Thermafiber® RainBarrier®**
- **WRB = 1.0 perm**
- **Exterior Gypsum**
- **Fiberglass Batt**
- **Interior Gypsum**

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

8C: **2x6** with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

8D: **2x6** with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

WALL ASSEMBLIES 9A–9D

WRB = 5 PERM

Assessment Criteria

Time of Wetness	0 T_1	500 T_2	1000 T_3	1500 T_3	2000 T_3	2500 T_3	3000 T_3	3500 T_4	4000 T_4	4500 T_4	5000 T_4	5500 T_4	6000 T_5
Mold	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

9A: 2x4 with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

9B: 2x4 with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

CONSTRUCTION 9:

- **Brick**
- **Air Gap**
- **Thermafiber® Rainbarrier®**
- **WRB = 5 perm**
- **Exterior Gypsum**
- **Fiberglass Batt**
- **Interior Gypsum**

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

9C: 2x6 with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

9D: 2x6 with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

WALL ASSEMBLIES 10A–10D

WRB = 10 PERM

Assessment Criteria

Time of Wetness	0 T_1	500 T_2	1000 T_3	1500 T_3	2000 T_3	2500 T_3	3000 T_3	3500 T_4	4000 T_4	4500 T_4	5000 T_4	5500 T_4	6000 T_5
Mold	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

10A: 2x4 with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

10B: 2x4 with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

CONSTRUCTION 10:

- **Brick**
- **Air Gap**
- **Thermafiber® RainBarrier®**
- **WRB = 10 perm**
- **Exterior Gypsum**
- **Fiberglass Batt**
- **Interior Gypsum**

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

10C: 2x6 with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

10D: 2x6 with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

WALL ASSEMBLIES 11A–11D

WRB = 30 PERM

Assessment Criteria

Time of Wetness	0 T_1	500 T_2	1000 T_3	1500 T_3	2000 T_3	2500 T_3	3000 T_3	3500 T_4	4000 T_4	4500 T_4	5000 T_4	5500 T_4	6000 T_5
Mold	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6

CONSTRUCTION 11:

- **Brick**
- **Air Gap**
- **Thermafiber® Rainbarrier®**
- **WRB = 30 perm**
- **Exterior Gypsum**
- **Fiberglass Batt**
- **Interior Gypsum**

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

11A: 2x4 with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

11B: 2x4 with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

11C: 2x6 with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

11D: 2x6 with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

WALL ASSEMBLIES 12A–12D

WRB = 120 PERM

Assessment Criteria

Time of Wetness	0 T_1	500 T_2	1000 T_3	1500 T_3	2000 T_3	2500 T_3	3000 T_3	3500 T_4	4000 T_4	4500 T_4	5000 T_4	5500 T_4	6000 T_5
Mold	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6

CONSTRUCTION 12:

- **Brick**
- **Air Gap**
- **Thermafiber® Rainbarrier®**
- **WRB = 120 perm**
- **Exterior Gypsum**
- **Fiberglass Batt**
- **Interior Gypsum**

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

12A: 2x4 with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x4			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

12B: 2x4 with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

12C: 2x6 with **Class III** Vapor Retarder — Latex paint only (8 perm)

2x6			Normal Moisture Load				High Moisture Load			
City	State	IECC climate zone	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year	Mold 1st year	Mold 2nd year	TOW 1st year	TOW 2nd year
Miami	FL	1A								
New Orleans	LA	2A								
Atlanta	GA	3A								
San Francisco	CA	3C								
Baltimore	MD	4A								
Seattle	WA	4C								
Portland	OR	4C								
Chicago	IL	5A								
Minneapolis	MN	6A								

12D: 2x6 with **Class II** Vapor Retarder — FSK Faced Batt (0.5 perm)

OWENS CORNING
ONE OWENS CORNING PARKWAY
TOLEDO, OH 43659 USA
www.owenscorning.com

Pub. No. 10026847. July 2024.