ROBUST WALLS WITH CONTINUOUS

FOAM PLASTIC INSULATION

Presented by:

covestro

LEARNING OBJECTIVES

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

1. Examine NFPA 285 approved wall assemblies that use foam plastic insulation in cavity walls and rain screens.
2. Understand how insulation manufacturers can assist architects in attempting to secure approval from code officials without first performing time consuming NFPA 285 tests on the wall assembly proposed for their project.
3. Describe the importance of using continuous insulation in wall assemblies.
4. Find alternative wall designs that might provide better insulating performance and better prevention of moisture penetration/accumulation than vapor permeable wall designs.

CONTINUING EDUCATION

CREDIT: 1 LU/HSW

COURSE NUMBER: ARoct2016.4

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INCREASED INSULATING PERFORMANCE OF WALL ASSEMBLIES

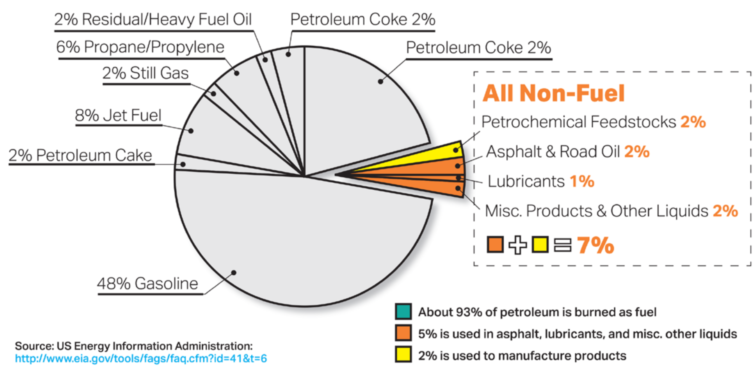
Many architects today and in the future will be looking for ways to increase the insulating performance of wall assemblies in order to meet increasingly stringent minimum energy code requirements. Using the highest R-value insulations, all other things being equal, would seem to make sense as a key measure in developing walls with greater insulation performance.

The idea that building design and material selection can impact occupant health has also landed on the architectural profession. Moisture accumulation and mold as a health issue must be addressed. Some believe that a wall must maximize its ability to dry out via vapor diffusion and related phenomena to efficiently prevent moisture accumulation, but that approach sacrifices thermal performance. There are other approaches.

Finally, misconceptions exist about foam plastic insulation preventing compliance with the IBC requirement concerning flame propagation. There are wall assemblies that are approved for NFPA 285 and manufacturers of polyurethane insulation that are ready to assist if code officials require an actual test.

Foam plastic insulation (polyiso board and spray polyurethane foam) can be used in code-approvable wall assemblies that work in cold, warm, marine and humid climates. Architects will be able to create alternatives to vapor permeable wall assemblies that address three main concerns: NFPA 285 flame spread tests, mitigating moisture retention within walls, and delivering higher insulating performance with great levels of comfort.

The International Building Code requires that walls with foam plastic insulation pass the NFPA 285 test. Image courtesy of Construction and Maintenance Solutions, LLC



Only 2% of all the oil harvested is used as feedstock for the manufacture of products such as wall insulation. Image courtesy of US Energy Information Administration (PVC) lack.

A Petroleum Bias

Many architects believe that using building materials comprised of petroleum is inherently bad. This is a common misconception that must be clarified. The fact is, approximately 93% of petroleum is burned as fuel, 5% is used in asphalt, lubricants, and other miscellaneous liquids, and only 2% of all the oil harvested is used as feedstock for the manufacture of products, such as wall insulation (plus many other products in construction, medical and other fields). As the chart above shows, this brings all non-fuel uses to only 7%. The major problems with petroleum arise when it is combusted as heating oil, diesel fuel, gasoline, jet fuel, propane, natural gas, or still gas, not when it's used to manufacture products.

Moving Toward Continuous Insulation (C.I.)

Continuous insulation is now the preferred, and often mandated, way to insulate a wall. Continuous insulation means placing insulation on the outside face of the sheathing so that it is not interrupted by studs inside the wall, which cause thermal breaks. There may or may not be a weather barrier in between the sheathing and the insulation. Some sort of weather barrier should always be used in the wall assembly. Foam plastic insulations tend to provide additional resistance to moisture penetration and absorption—a useful redundancy—while fibrous insulations absorb the moisture.

LEED projects mandate continuous insulation, but in general, it is considered a basic design solution for improving the energy efficiency of walls, and is becoming the norm even if not yet required by code everywhere.

Another phenomenon is that building energy usage is being driven lower, so older wall designs no longer work. For example, in the past architects could incorporate more robust HVAC systems to help dry out walls, but the more energy efficient HVAC systems that are now required no longer serve this auxiliary purpose; the walls now have to dry out on their own. Therefore, as we drive overall energy usage down, wall design and moisture management are becoming ever more important. Continuous insulation can be one part of the solution to this conundrum.

NFPA 285

Foam plastic insulation is the generic term for polyiso board, spray polyurethane foam, expanded polystyrene, and extruded polystyrene. These are all insulations that are made from oil.

The International Building Code requires that walls with foam plastic insulation pass the NFPA 285 test, aka Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components.

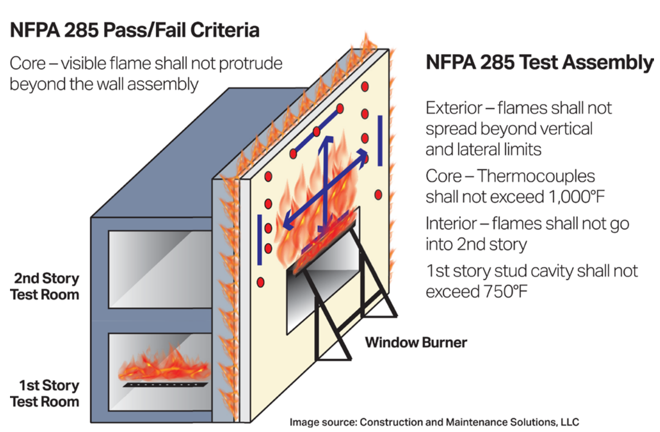
Many are unaware that some insulation manufacturers have pre-emptively and successfully tested wall assemblies using foam plastic insulations to help guide architects and code officials in making choices about how walls are designed, and to aid those seeking less energy use and better thermal comfort for occupants.

This diagram demonstrates what the test looks like. The test begins with a five-sided concrete box; the sixth side is where a company builds their wall to be tested. The wall is always the same dimension, always has windows in the same place, and is always set on fire in the same ways.

The fire is first introduced inside the lower floor with the room burner. After a short period of time the fire is introduced within the thickness of the wall at the window burner. These two sources of flame are designed to simulate how fires may get into a wall and how flames can spread through the wall.

In order to pass the test, the exterior flames must not spread beyond vertical and lateral limits; these limits are five feet left of, right of, and below the center, plus 10 feet above the window opening. If there is any visible evidence of fire even one inch beyond these limits the wall assembly fails.

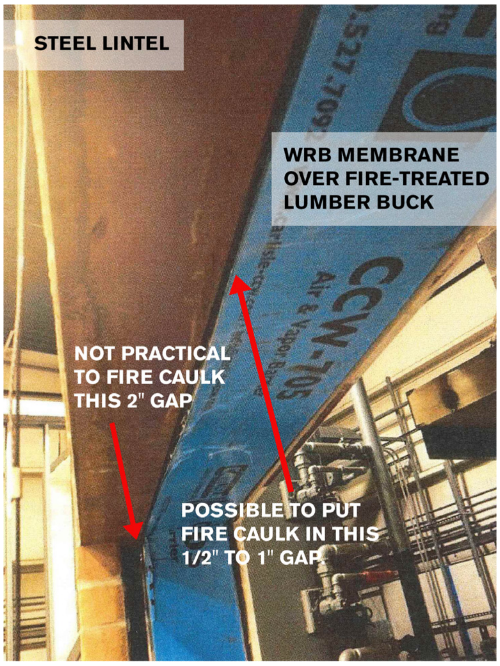
In addition, thermocouples read the temperature inside the wall. The core temperature may not exceed 1,000 degrees Fahrenheit and visible flames should not protrude beyond the wall assembly. There is a 1st story and a 2nd story test room; the interior flames should not go into the 2nd story. The 1st story stud cavity should not exceed 750 degrees Fahrenheit. And finally, there can be no appearance of flames at the edges of the wall assembly.



In order to pass the test the exterior flames must not spread beyond vertical and lateral limits; these limits are five feet left of, right of, and below the center, plus 10 feet above the window opening. Image courtesy of Construction and Maintenance Solutions, LLC

As you can see, this is a time-consuming test to run, and it's expensive, but the results are clear.

Hurdles include not only the cost, but also the time it takes to schedule the test, build the wall assembly at the test site, and then actually conduct the test. The time required is often more of an issue with building owners than the cost of the test since a part of the building design may remain unresolved until the results of the test are known.



VIEW BENEATH WINDOW HEAD

Protect sensitive materials by blocking fire and heat from getting into the wall cavity at the window head. Image courtesy of Carlisle Construction Materials and Construction and Maintenance Solutions, LLC.

Wall Assembly Details and NFPA 285

It is not just one material that helps a wall assembly pass NFPA 285; it's an assembly. A poorly detailed wall may fail using the same products as a better-detailed wall. Window head details can make or break the NFPA 285 results, so it is an important strategy to protect temperature and flame sensitive materials by blocking fire and heat from getting into the wall cavity at the window head. Steel, concrete, masonry, mineral wool, fire-rated gyp board, fire-treated lumber, and/or intumescent caulk may be required.

This image shows the view beneath the window head. At the top of the window head, flammable and semi-flammable weather barriers are introduced over the fire-treated lumber, closing off the inside face of the wall (blue material). The wall assembly in this image has a steel lintel on the outside, but there is a two-inch air gap between the vertical studs (jamb) which are also covered in the blue weather barrier, and the insulation. It is possible to fire caulk the narrow ½"–1" gap at the head. But you can't caulk the 2" gap at the jamb. With this wide gap, many assemblies will fail the NFPA 285 test. In many cases, blocking off the gaps is an essential part of wall assembly design no matter what insulation is used.

Wall Assemblies—XPS Insulation

Extruded polystyrenes (XPS) are thermoplastic insulations by classification, meaning that they do not resist heat and fire well. When exposed to enough heat they can lose their shape. When they catch fire, and when on fire, material on fire drips from the board.

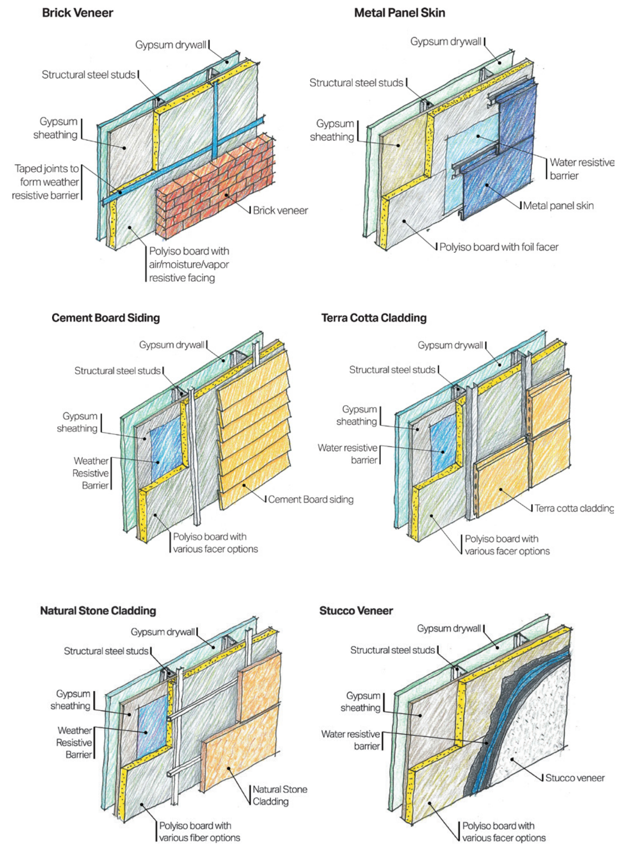
In most roof and wall assemblies seeking a fire rating that are constructed with extruded polystyrene, another layer of protective material must be placed between the flame and the XPS to prevent the XPS from directly contacting the flame and absorbing too much heat or catching on fire.

Window Head Condition—Polyiso Insulation

By contrast, polyiso board is a thermoset product, which means that it won't change shape or disintegrate when exposed to flame. It burns, then chars, which retards flame propagation to a certain degree. This is why it can be set in window openings in wall cavities without other protective material between the insulation and the window opening in many NFPA 285 compliant assemblies. Other reviewing agencies such as the insurance oriented FM Global may have additional requirements. It is advisable to check with the building owner's insurance carrier for any additional requirements they might have beyond building code compliance.

For a long time, code officials ignored the code requirement for testing walls containing foam plastic insulation. Then, with the advent of continuous insulation, the NFPA 285 test became more often required by code officials. The required tests on these known insulations and wall assemblies can take $15–$30,000 or more to erect the wall at the testing site and then run the test. It can take three to four months waiting in a queue to get an assembly tested. As you can imagine, it's difficult to convince a client to either delay a project for that long or incorporate the required time into the original schedule when neither is a normal part of project development.

This is why a number of polyiso board manufacturers have preemptively built and tested a number of wall systems constructed of various materials for NFPA 285. If one of



Foam plastic insulation in six NFPA 285 walls. Images courtesy of Covestro

these walls is close enough in design to the wall you are constructing, you can present an engineering report to your code official, showing that a sample/similar wall passed.

You may then not have to perform the test yourself because the wall assembly already tested satisfies the code official's concerns.

Whether you have to do an actual test or not, by doing all these NFPA 285 tests preemptively, certain polyiso manufacturers are now very knowledgeable and could help anyone who's contemplating designing a wall with polyiso insulation in it.

FOAM PLASTIC INSULATION IN NFPA 285 WALLS

Let's look at these six illustrations, each showing steel stud walls with polyiso board continuous insulation. All have passed NFPA 285, and have a variety of 3rd party engineering opinions that expand the applicability of the testing. The first is a typical brick veneer wall with steel studs. Next to it is an un-insulated metal panel skin, a very different type of veneer. One would think that the brick would actually help with the flame-spread, but right next to it is a wall assembly that just has pieces of metal. This shows that the polyiso board and other thermo-set insulations can resist flame spread, irrespective of the cladding without additional protection or unusual additional materials.

Cement board siding is a typical cladding material. Next is a terra cotta rainscreen, which is designed so that air moves between the insulation and the back of the cladding, yet it still passes the NFPA 285 test. Finally, both natural stone cladding and traditional stucco veneer with polyiso insulation passed the test.

Some insulation manufacturers have 3rd party NFPA tests for certain wall assemblies. These assemblies are a combination of building envelope skins, steel studs, and polyiso board insulation. NFPA 285 compliant wall assemblies that have been preemptively tested successfully include components such as the following:

The skins include:

- Brick veneer
- Stucco (minimum ¾" thick with exterior lath)
- Limestone veneer (minimum 2" thick)
- Cast stone veneer (minimum 2" thick)
- Natural stone veneer (minimum 2" thick)
- Metal composite material (MCM)
- Terra cotta cladding (1-1/4" thick minimum)
- Metal panels
- Cement board siding

Manufacturers successfully tested the same wall assembly with different types of polyurethane insulation board products. Each of these skins have passed NFPA 285 burn tests using the following insulation board products:

- Polysio board with coated glass mat facers and WRB
- Polysio board with foil facers and WRB
- Polysio board with nailable fire-treated wood panels and WRB
- Polysio board with air/moisture/vapor resistant facer, taped board joints and no WRB

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QUIZ

1. Approximately _____% of petroleum is burned as fuel, while only ______% of all the oil harvested is used as feedstock for the manufacture of products.
   a. 10, 80 b. 93, 2
   c. 80, 7 d. 25, 75

2. Foam plastic insulations tend to provide additional resistance to moisture penetration and absorption while fibrous insulations absorb the moisture.
   a. True b. False

3. The International Building Code does not require that walls with foam plastic insulation pass the NFPA 285 test.
   a. True b. False

4. Polyiso board is a thermo-set product, which means that it won't change shape or disintegrate when exposed to flame.
   a. True b. False

5. Which type of wall resists moisture penetration while allowing drying toward the interior if/when moisture gets in?
   a. Higher perm b. Lower perm

6. A rigid board will remain rigid and resist air penetration, while fiberglass or mineral wool insulation will not stop moisture from entering the stud cavity via air leakage.
   a. True b. False

7. In Building Science Corporation tests, walls with continuous insulation in the Pacific NW keep their sheathing moisture content below 20 percent almost year-round, protecting the interior surface temperature of the sheathing from getting cold enough for condensation.
   a. True b. False

8. Which of the following are true?
   a. Highly permeable walls allow moisture in vapor form to pass through
   b. High perm insulation retards moisture from air leakage inside the wall
   c. Vapor diffusion can be relied upon to drive moisture out of walls all of the time
   d. Low perm walls keep out moisture from air leakage and vapor drive
   e. Low perm walls save HVAC energy when they prevent moisture from entering the building
   f. A, D, and E
   g. All of the above

9. Continuous insulation foam plastic insulation walls that are vapor-impermeable have the lowest wintertime air leakage and lowest wintertime sheathing moisture content.
   a. True b. False

10. Which of the following is a benefit of continuous low perm foam plastic insulation as a wall design strategy?
   a. Control bulk moisture from precipitation
   b. Control air penetration and air leakage into the wall
   c. Maintain warmer temperatures within the stud cavity
   d. Control moisture penetration via vapor drive
   e. B, C and D
   f. All of the above

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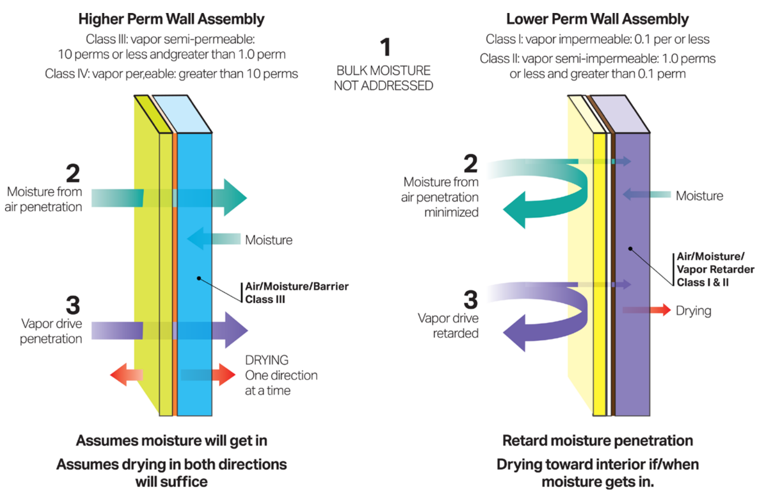


Low perm walls accept less moisture.

Vapor Impermeable Insulations and Moisture Control in Walls

As we briefly discussed earlier, in enclosed buildings that are using less and less energy to keep people comfortable inside, the walls have to work harder on their own to keep the elements out. They must maintain durability and not allow moisture to accumulate.

There are two kinds of walls to compare, a higher-perm wall assembly, and a lower-perm wall assembly. The higher the perm rating, the higher the numbers, and the more easily moisture in the form of vapor can penetrate right through a material. Conversely, the lower-perm wall with the lower perm number keeps more moisture from penetrating through the material into the wall.

The different classes of air/moisture/vapor retarders are as follows:

- Class I: vapor impermeable: 0.1 perm or less
- Class II: vapor semi-impermeable: 1.0 perms or less and greater than 0.1 perm
- Class III: vapor semi-permeable: 10 perms or less and greater than 1.0 perm
- Class IV: vapor permeable: greater than 10 perms

A higher perm wall assembly utilizes highly permeable insulation with a Class III or IV air/moisture retarder. A higher permeable wall assembly assumes that moisture will get in, and assumes that it will dry out in either direction—one direction at a time—caused by vapor pressure, temperature or humidity differentials. Lower perm wall assemblies use impermeable insulation and a Class I or II air/moisture/vapor retarder. A lower permeable wall assembly retards moisture penetration, but allows drying toward the interior if/when moisture gets in.

We must note that bulk moisture is not addressed here. Bulk moisture is the number-one cause of moisture penetration and accumulation in a wall, according to forensic building experts. Bulk moisture is caused by things such as a hole in the wall, a bad flashing detail, or some other issue that arises due to how the wall was constructed; not the materials used.

Low-Perm Walls Accept Less Moisture

The second-most important and impactful way to compromise the integrity of walls is moisture in the air. If a wall allows air to enter, moisture in the air will also enter. In a higher-permeable wall assembly, air can get into many types of walls, which is proven by testing. Proponents say that, yes, while air can get through, moisture will dry out. It gets in easily, but it dries out easily.

The higher-perm wall depends on moisture being able to move through it, which is based on temperature, humidity and vapor pressure phenomenon. By contrast, the lower-perm wall assembly, like those featuring polyiso and spray foam polyurethane, keeps out as much moisture as is reasonably achievable from the get-go, because the insulation resists water absorption. In addition, you can cut and fit polyiso boards tighter against wall assembly components, allowing less air into the walls, so moisture from air penetration can be minimized.

Finally, the third-most impactful way that moisture gets into the wall is vapor, which is the perm rating we've been talking about. Moisture gets through the building skin and into the wall cavity. Vapor drive causes the moisture collected in the wall cavity to attempt to penetrate through the wall assembly into the interior of the wall.

Vapor drive occurs because the cavity heats up, creating pressure. Moisture takes the path of least resistance through a fibrous insulation, then through a weather barrier that doesn't retard vapor, and then into the interior of the wall. The temperature differences and the vapor pressure developed must be great enough to drive the moisture through the wall components and out of the wall. Temperature and vapor pressures may not be great enough to cause vapor movement. The moisture may remain too long in a wall because conditions are not conducive to moving it. Again, by contrast, the low-perm wall containing low perm polyiso board insulation resists vapor penetration to begin with, making it harder for the moisture to enter the stud cavity and accumulate.

BUILDING SCIENCE CORPORATION TESTED WALL ASSEMBLIES—PACIFIC NW

Building Science Corporation performed testing and modeling for moisture penetration using models of different wall assemblies. The common construction components for all walls were:

- Fiber cement siding
- ½" x 2" treated furring strips
- Gypsum wall board interior finish with Class III vapor barrier latex paint

Note that some of these walls don't have continuous insulation but rather only insulation in between the studs. They also are using components that aren't designed to resist moisture penetration from vapor drive. But they are tested primarily because these walls with high perm insulation and other high perm components are still used a lot, particularly Walls 1 and 2.

Wall 1 is comprised of fiberglass batts in between the studs, with vapor-permeable weather barriers on both sides. The other two walls have wall stud cavities filled with foam. The top one is closed-cell, which is denser and has a higher R-value, while the bottom one is open-cell, which is less dense, has a lower R-value, and is generally less expensive.

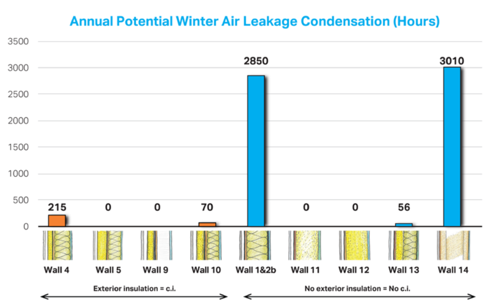
The other walls tested are all commonly used. A flash-and-batt wall has spray foam insulation against the inside face of the sheathing in the stud cavity. Spray foam expands into the nooks and crannies and is vapor-impermeable, so it is used to try to stop the vapor drive and seal the wall cavity. For cost reasons, the balance of the cavity is then filled with fibrous batt insulation.

Another type of assembly is a very wide wall filled with cellulose, which has a lower R-value. In order to achieve high R-value walls, they are built with thick 15-, 18-, or 24-inch-wide walls with double studs, then filled with cellulose.

Some of the walls tested do use continuous XPS foam plastic insulation with a fairly permeable SBPO air/water barrier that does not resist vapor. The inside of the stud cavity is then filled with fibrous batt insulation. Both 2" and 4" XPS insulation were tested in this type of wall. The assembly with twice as much continuous insulation has an R-value of 37.3 as opposed to 27.2.

The first truly vapor-impermeable wall design tested, Wall 9, is one where the weather barrier is actually an air, water, and vapor barrier, and the foam plastic insulation is fairly vapor-impermeable as well. The stud cavity is left empty.

The same wall was then used, but the stud cavity was filled with fiberglass batt, in order to

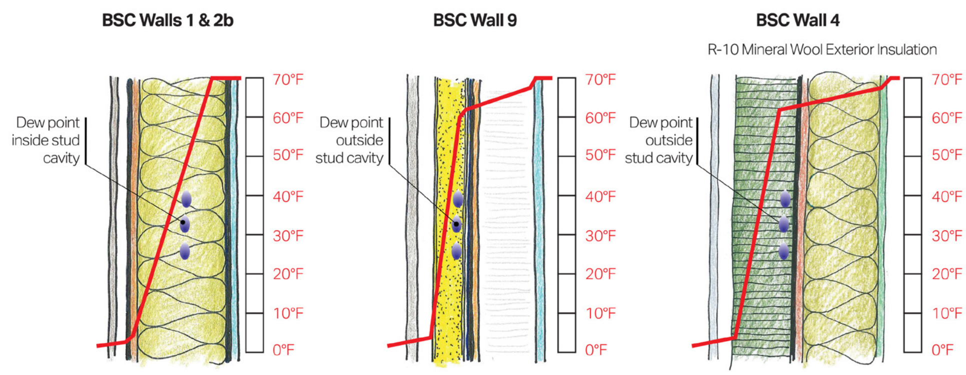


More enclosure failures are caused by air leakage condensation than by vapor diffusion condensation.

get a higher R-value.

Walls with C.I. SPF Showed Little Air Leakage

What did Building Science Corporation learn from this test? In the Winter Air Leakage Condensation Potential—Hours Annually chart above, the walls in the chart are divided into walls that have exterior or continuous insulation (on the left) and walls that have no exterior continuous insulation (on the right)—all insulation is between the studs with nothing



Foam plastic and mineral wool C.I. both keep the sheathing interior surface warm.

but sheathing, weather barrier, and skin between the inside of the wall and the outside.

The condensation potential due to winter air leakage is the second-most impactful type of failure in walls, and is measured in hours of potential problems. This is based on surface temperatures on the inside sheathing face. When the sheathing gets cold, any moisture that the air is holding will condense on the cold sheathing surface, and then moisture will accumulate.

Therefore, walls that are highly vapor permeable have a very large amount of time where they could be susceptible to condensation because of their permeability. By contrast, even though they don't have continuous insulation, Walls 11, 12, and 13 have very low potential for air leakage. This is because they have foam insulation, which is vapor-impermeable and otherwise resistant to absorbing moisture. This is extremely important, as is the fact that foam insulation provides a very tight fit. A rigid board will remain rigid and resist air penetration, while fiberglass or mineral wool insulation will not stop moisture from entering the stud cavity via air leakage.

Continuous Insulation Works with High R-Value

Continuous insulation tends to prevent the dew point from occurring inside the stud cavity.

Even a fibrous insulation such as mineral wool used as exterior continuous insulation (shown in Wall 4) will do a good job of keeping the interior face of the sheathing warm and thus free of condensation. Walls 1 & 2b have the red line showing the temperature gradient from the outside where it's zero degrees to the inside where it's 70 degrees. There is potential for condensation to occur on the steel surfaces of the stud and the inside face of the sheathing anywhere from 0 degrees to 50 degrees. This occurs within the stud cavity in Walls 1 & 2b.

Wall 9 demonstrates that the temperature differential is dealt with in the continuous insulation. By the time the air reaches the sheathing, it's already protected. It hasn't lost as much energy to the outside, and is still fairly warm. Because it's still fairly warm, the temperature inside that stud cavity doesn't allow condensation.

Even Building Science Wall 4, which uses mineral wool as its continuous insulation, prevents condensation by protecting the inside surface of the sheathing. This wall isn't vapor resistant, but it does stop condensation caused by temperature gradient.

In the Walls 1 & 2b, condensation tends to occur on the inside face of the sheathing. Mold and then rot can occur where water accumulates inside the wall. When a wall is full of spray polyurethane foam that resists moisture penetration and resists vapor drive, there's no place for moisture to go, and no place for air to get in, which is why that wall works. The condensation plane is kept on the outside.

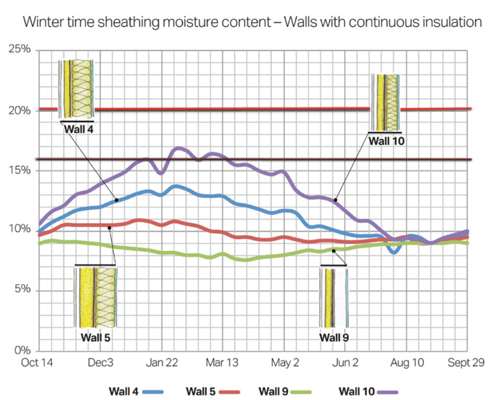
High Perm Continuous Insulation Still Might Have Vapor Pressure Issues

Looking at the higher-perm mineral wool assembly that uses continuous insulation, everything seems fine, but because it still allows vapor penetration through the wall materials, there still is a potential for condensation to occur on that inside sheathing surface. The problem that you have with this wall is not only is moisture coming from the outside, but moisture can come from the inside. The inner wall surface can actually get too cold because room air temperature cannot reach it. Even though it does a good job with the temperature gradient issue, it is still susceptible to vapor drive. Vapor drive is the third most impactful phenomenom that can bring moisture into a wall so it may not often be a problem in some climates. However, the fact that moisture can enter the high perm wall from both directions even if a wall has a "smart vapor barrier" behind the drywall, can leave things to chance.

Winter Time Sheathing Moisture Content—Walls without C.I. in Pacific NW

Looking at the two basic categories of walls and the sheathing moisture content as modeled by WUFI, you see that all of the walls without continuous insulation have trouble. They spend 20 weeks with the potential for the sheathing moisture content to get above 20 percent, which is generally considered to be the maximum moisture content before problems could occur. For almost 40% of the year, sheathing is in danger of being exposed to moisture. At a more comfortable 16%, sheathing moisture content is too high for half of the year.

By contrast, walls with continuous insulation keep their sheathing moisture content below 20 percent year-round, protecting the interior

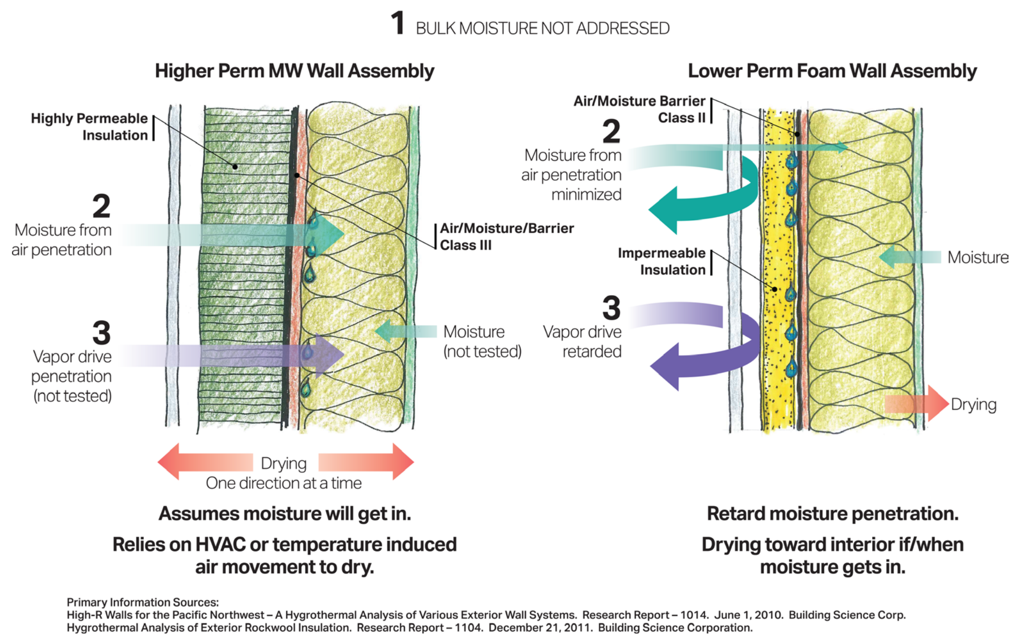


Foam plastic continuous insulation poses little danger to sheathing.

surface temperature of the sheathing from getting cold enough for condensation.

Low-Perm C.I. is Solution for the South

In the southern United States the problem is much simpler. For most of the year it's hotter and more humid on the outside of the building and cooler and drier inside because it's air-conditioned much of the year. Moisture and



Low perm walls with C.I accept less moisture.

temperature drive always goes from hot to cold and from wet to dry. The wall only has to resist these forces in one direction—from the outside.

The low-tech fiberglass wall that is commonly built is much more susceptible to moisture penetration in the south. The only way this wall will dry is if the air conditioning does it, which will then use more energy. It might then be very hard to be a high-performing, low energy-usage building.

The wall with mineral wool in the continuous insulation slot will do better, but again, it still allows moisture to enter. When the moisture enters, the moisture will move inward. What happens to the interior of the wall as time elapses with moisture inside?

An all-masonry wall, which has been used in the south for years is next. A mass wall works primarily because the mass of concrete or masonry absorbs an incredible amount of moisture and that absorption helps keep the moisture from penetrating inside and impacting the interior. The problem with this wall is that it's more expensive than frame walls, so it's not built as frequently.

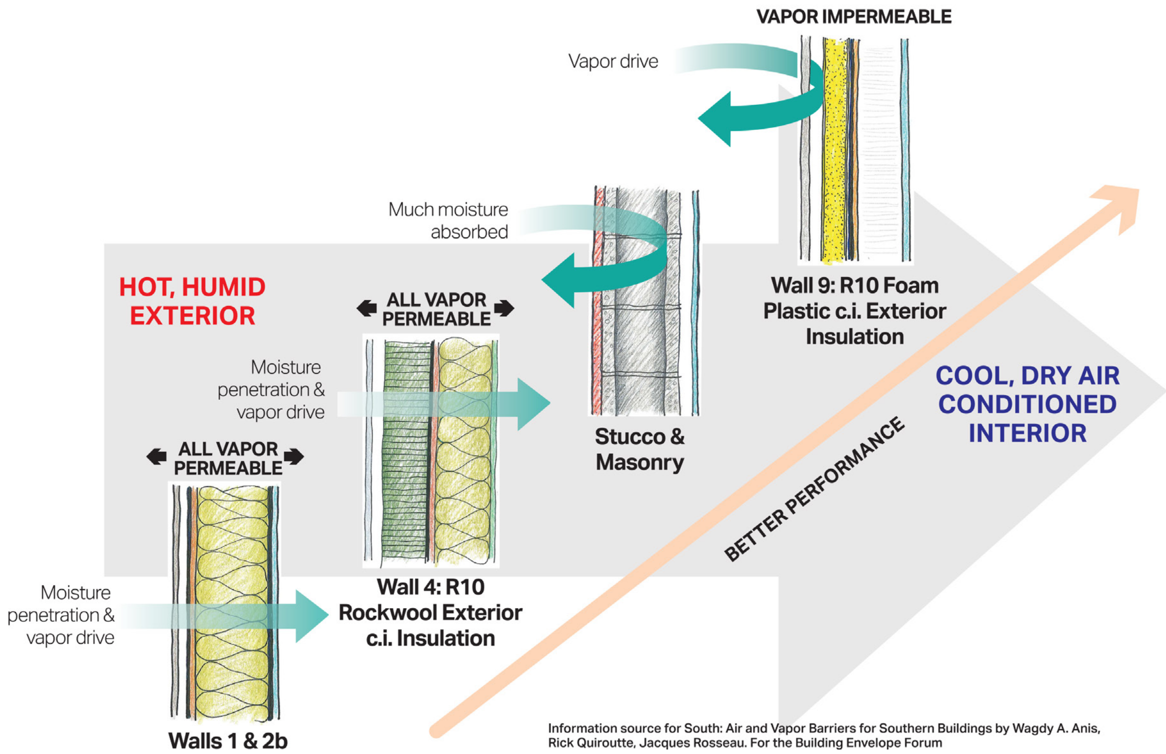
Finally, the wall at the top with foam plastic c.i. exterior insulation is vapor-impermeable. It's perfect for the south because it doesn't let much moisture in, and it doesn't absorb moisture like fibrous insulations. It's also not letting air in because boards and/or foam insulation can be cut to fit tight against adjacent construction. Then they are sealed. These walls do not let vapor in because it doesn't allow vapor to drive through it. Performance improves as you move from one wall up to the next on this chart because the danger always arises from the outside in.

Wall Insulation—A Foam Plastic Insulation Solution for Many Conditions

In summary:

- Highly permeable walls allow moisture to pass through in vapor form.
- High perm walls have the potential to burden the HVAC with more load.
- High perm insulation absorbs moisture from air leakage inside the wall.
- Vapor diffusion depends on weather conditions and cannot necessarily be relied upon to drive moisture out of walls all of the time.
- Low perm walls keep out moisture from air leakage and vapor drive.
- Low perm walls save HVAC energy when they prevent moisture from entering the building.

Vapor permeable walls without continuous insulation have the highest wintertime air-leakage potential. They also have the highest wintertime sheathing moisture content, spending more time above the 20 percent



Low perm walls keep out moisture from air leakage and vapor drive, and also save HVAC energy.

content than the other walls. The condensation surface is routinely within the stud cavity, which is where mold could grow. In addition, these walls often have the lowest R-values because high perm insulation has the lowest R-values. High perm walls with high R-values can be constructed, but they still have the same problems with regard to moisture absorption and vapor drive.

By contrast, continuous insulation foam plastic insulation walls that are vapor-impermeable have the lowest wintertime air leakage and lowest wintertime sheathing moisture content. Condensation routinely occurs only on the outside of the stud cavity because it can't get through the insulation. They also have the highest R-values.

Based on all of this research and tests, it is apparent that a low-perm, moisture-resistant insulation is the material of choice.

The recommended wall design strategy is to require continuous low perm foam plastic insulation for the following reasons:

- Control bulk moisture from precipitation.
- Control air penetration and air leakage into the wall.
- Maintain warmer temperatures within the stud cavity to avoid condensation on the interior side of the sheathing.
- Control moisture penetration via vapor drive. ■

NO Exterior Insulation (c.i.) /Vapor Permeable
Highest winter time air leakage potential
Highest winter time sheathing moisture content. Above 16%.
Condensation surface within stud cavity
Lower R values

Exterior Foam Plastic Insulation (c.i.) / Vapor Impermeable
Lowest winter time air leakage potential
Lowest winter time sheathing moisture content. Below 16%.
Condensation surface outside of stud cavity
Higher R values