A COMPLETE ENVELOPE SOLUTION WITH INSULATED METAL PANELS

Presented by:

METL SPAN®

LEARNING OBJECTIVES

Upon completion of this course the student will be able to:

1. Identify how to control building enclosures.
2. Examine how complex energy codes are simplified when using insulated metal panel systems.
3. Describe the advantages of insulated metal panels compared to alternative building systems.
4. Examine design options for aesthetics, including standard panel options and high performance continuous insulation barrier panels.

CONTINUING EDUCATION

CREDIT: 1 LU

COURSE NUMBER: ARjune2016.4

Use the learning objectives above to focus your study as you read this article. To earn credit and obtain a certificate of completion, visit http://go.hw.net/AR616Course4 and complete the quiz for free as you read this article. If you are new to Hanley Wood University, create a free learner account; returning users log in as usual.

PHYSICS OF BUILDING ENVELOPES—HYGROTHERMAL LOADS

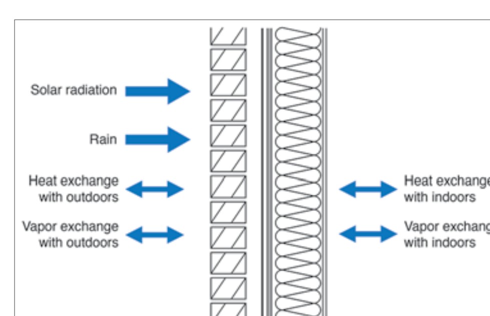
The building envelope separates the building interior from the outside environment. Environmental loads, as they were historically called, are characterized as combined heat, air, and moisture (HAM) transport that act on both the exterior and interior of a building enclosure. Today, these loads are referred to as hygrothermal loads and the process of evaluating their effect on building enclosures is called hygrothermal analysis. The key hygrothermal control requirements for building enclosures are control of heat flow, air flow, water vapor flow, rain, and ground water.

These control requirements are governed by the Laws of Thermodynamics. Of the four Laws of Thermodynamics, the 2nd law is the most misunderstood and most relevant to environmental separation. The 2nd law can be summarized as follows:

- Heat flow is from warm to cold.
- Moisture flow is from warm to cold.
- Moisture flow is from more to less.
- Airflow is from higher to lower pressure.
- Gravity acts downward.

In order to control all of the hygrothermal loads, the following building envelope components are needed, in order of importance:

- Water control layer
- Air control layer
- Vapor control layer
- Thermal control layer



Typical hygrothermal loads acting on building enclosures. The loads act on both sides of an assembly, from the exterior and the interior.

CONTROL LAYERS

All control layers are important, but not equally important in terms of envelope durability. The order of importance is drawn from historic experience and the underlying physics of each layer. For centuries, controlling water in the liquid form (rain and ground water) has been the chief goal of master builders and architects. It wasn't until the past century that a focus on controlling air arose; controlling vapor has been an even more recent development within the past couple of decades.

The water control layer controls bulk water such as rain and ground water (as opposed to water vapor or condensation), and provides the most basic protection from the elements. This task is performed by an exterior cladding element.

The air control layer controls air leakage, preventing "drafty" buildings. It provides airtightness and can include exterior cladding with sealants or films, coatings, and membranes. Air movement transports a lot more water in vapor form than vapor diffusion does.

The vapor control layer manages vapor diffusion, which is the movement of vapor even without air movement. The vapor control layer regulates the movement of vapor from one side to the other; the materials used can also be called retarders or barriers. Proper vapor control depends on the climate zone, insulation system, building use, and interior conditions.

Vapor retarders come in three classifications:

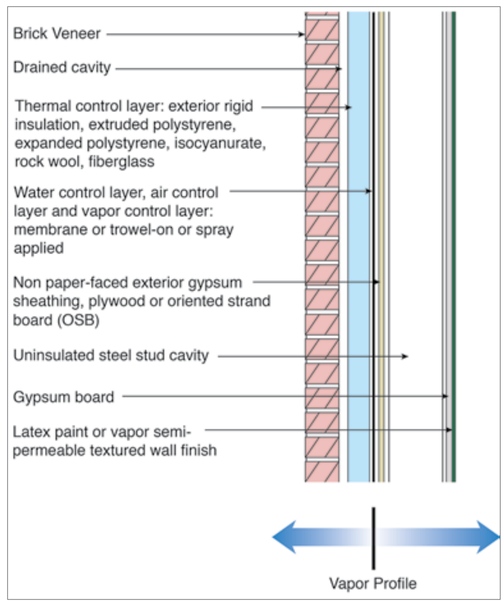
- Class I: < .1 perm (impermeable)
- Class II: > .1 perm < 1.0 perm (semi-impermeable)
- Class III: > 1 perm < 10 perm (semi-permeable)
- 10 perms = NOT a vapor retarder (considered permeable)

Vapor control layers can consist of any of the following:

- Latex paint or semi-permeable textured wall finish on interior gypsum
- Polyethylene sheathing behind interior gypsum wallboard
- Vinyl facing on batt insulation
- Interior face of insulated metal panels
- Air/water barriers

Finally, the thermal control layer controls heat loss and gain, which can have a significant impact on comfort, operating and energy costs, and sustainability. Thermal control layers consist of various forms of building insulation, including cavity systems (batt insulation), spray foam, rigid board, and insulated metal panels.

Thermal control dates back millenniums, but has typically only lead to comfort or operating cost issues rather than structural failure. Hence, thermal control layers are listed last on the control layer "priority" list.



The "Perfect Wall" is the optimum configuration of the control layers for a wall assembly.

PERFECT WALLS

The "perfect wall" or "universal wall" is the optimum configuration of control layers for a wall assembly. Water, air, and vapor control layers are all located on the exterior of the structure, while thermal control is located outboard of the other control layers. The water, air, and vapor control layers are usually combined into a single layer comprised of a film, coating, membrane, or sheet good.

This perfect wall can be used in all climate zones, including cold, mixed, hot, humid, dry, or marine. The system works for all interior environments including office, residential, institutional, pools, museums, art galleries, and data processing centers. The sole exceptions are refrigerated buildings and cold storage facilities. In such assemblies the location of the thermal control layer is "flipped" so it is located on the interior of the other three control layers.

CLIMATE ZONES

The U.S. climate zones are defined by ASHRAE. In cold climates, locating the vapor control layer on the interior of the thermal control layer keeps it warm, therefore controlling condensation from occurring due to interior moisture sources.

In hot climates, locating the vapor control layer on the exterior of the structure allows condensation to drain that may occur on the exterior surface of the control layer. This condensed water is handled in the same manner as penetrating rainwater. Note the water control layer and vapor control layer are in the same location and are typically the same material.

In mixed climates, the configuration controls interior moisture loads during the heating season in the same manner a similar assembly controls interior moisture loads in cold climates. During the cooling season the configuration addresses exterior moisture loads in the same manner a similar assembly addresses exterior moisture loads in hot climates.

You can see why an assembly that locates the water, air, and vapor control layers on the exterior of the structure, with the thermal control layer outboard of the other control layers, is referred to as the "universal wall" or "perfect wall." It works in all climate zones for all interior environmental conditions with the exception noted.

HYGROTHERMAL ANALYSIS

This configuration does not require hygrothermal analysis such as Warme und Feuchte Instationar (WUFI) modeling in any climate zone. In cold climates, or in any climate zone during heating months, dew point calculations or hygrothermal modeling are not necessary regardless of the interior moisture load. This is because all of the insulation is external to the air control and vapor control layer.

In hot, humid climates or any climate where air conditioning is occurring, dew point calculations or hygrothermal modeling are again not required. Condensation can only occur, if it occurs at all, on the exterior surface of the water, air, and vapor control layer where it can drain to the exterior in the same manner that rain penetration is controlled.

CREATING A PROPER BUILDING ENVELOPE—ROOFS, SLABS, AND WALLS

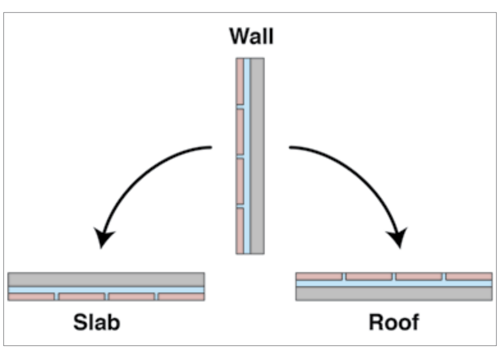
Going back to the optimum configuration of the control layers for a wall assembly, or the "perfect wall," let's discuss the functions of cladding and control layers.

The four functions of cladding are to:

- protect the control layers from exposure to ultra-violet radiation

- reduce the rain load on the control layers
- provide physical protection to the control layers
- provide aesthetics

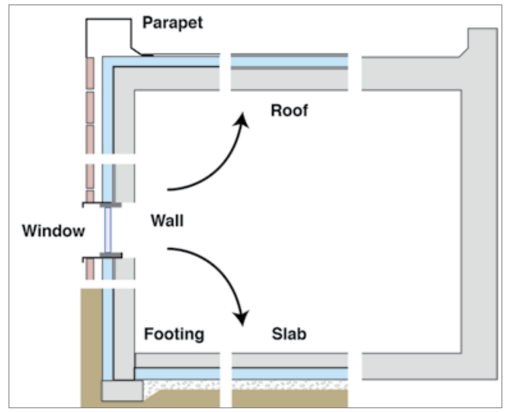
The cladding is drained and back-ventilated in such assemblies. The function of the drainage plane is to control hydrostatic pressure that may result from penetrating rainwater, while the function of the back-ventilation is to promote evaporation of moisture on the drainage plane and reduce inward vapor drive, especially when using "reservoir" claddings such as brick or masonry. Reservoir claddings store moisture during rain events, then create a large inward vapor drive when exposed to solar radiation (heat gain), causing dangerous summertime condensation within wall cavities.



Similar loads and the laws of physics apply to all elements of the building enclosure.

Because similar loads and the same laws of physics apply to roofs, slabs, and walls, the same approaches can be applied to each element of the building envelope. A typical roof membrane provides air, water and vapor control above the thermal control layer (insulation). A second membrane or layer is provided below the thermal control layer and functions as air control and vapor control. The intent is to keep the rain, air, and vapor from entering the assembly from the top (outside) and to keep the air and vapor from entering the thermal control layer from the bottom (inside). Such an assembly works in all climate zones and all interior environments, even refrigerated buildings and cold storage facilities.

The key to the performance of a slab foundation assembly is the granular or stone layer under the thermal control layer (insulation) that functions as a capillary break to control liquid water absorption in the thermal control layer. It is analogous to the "drained and back-ventilated" cladding of a wall assembly.



This is a conceptual approach to a building enclosure—an idealized enclosure with continuity of the control layers for the parapet, roof, wall, slab, and punched openings.

CONTROL LAYER CONTINUITY

Roof assemblies, wall assemblies and foundation assemblies subsequently need to be integrated to function as a building enclosure. The water control layer of the roof assembly is connected to the water control layer of the wall assembly that is then connected to the water control layer of the slab/foundation assembly. Then the air control layer of the roof assembly is connected to the air control layer of the wall assembly that is then connected to the air control layer of the slab/foundation assembly. The same conceptual approach is applied to the vapor control layer and thermal control layer.

Continuity of the control layers is key to the hygrothermal performance of building enclosures. Historically, continuity has been most significant at transitions between different building elements such as where roofs meet walls, and at penetrations such as punched openings for windows, doors, curtain wall connections, storefront connections, and service openings for mechanical, electrical, plumbing, and communication.

INTRODUCTION TO INSULATED METAL PANELS

The two most common versions of the site-built universal wall or perfect wall are masonry or concrete assemblies and steel frame assemblies. In both of these assemblies a myriad of products work successfully, including most exterior insulation and most sheet good, spray system, or trowel-applied membrane products, as long as they are installed correctly. Note the vapor profile at the bottom of the figure on the next page. Drying occurs to the interior from the bold line and to the exterior from the bold line in all climates.

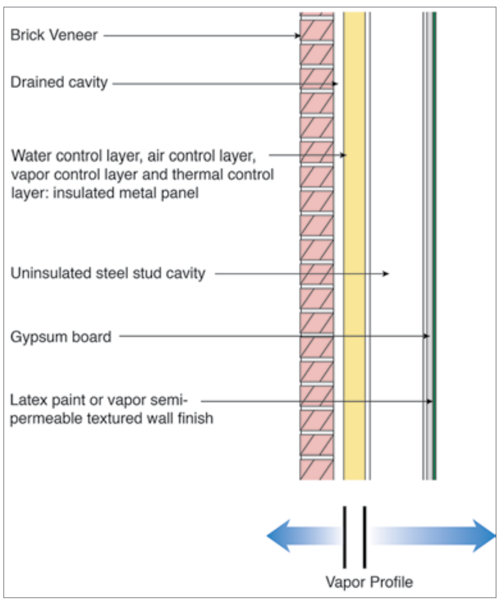
Insulated metal panel systems (IMPs) as a rainscreen barrier are a pre-manufactured version of a perfect wall. They consist of two single-skin metal facings and a foamed-in-place polyurethane core.

As discussed earlier, dew point calculations or hygrothermal modeling is not required in any climate zone when all of the insulation is located external to the air and vapor control layer, with the stipulation that no interior vapor barriers are installed on the interior of the assembly.

Insulated metal panel (IMP) systems as a rainscreen barrier are a pre-manufactured version of a perfect wall. They consist of two single-skin metal facings and a foamed-in-place polyurethane core. The metal and foam composite construction creates a rigid panel far stronger than the individual parts. This increases the span capability of the panels and reduces the need for secondary structural steel components.

IMPs are sealed to each other at the side laps and to the substructure at all perimeter boundaries, which make them the ideal choice for applications where a continuous air barrier is required. The special foam insulation of IMPs offers superior R-values that provide enhanced energy performance. Both faces have a tongue and groove joint, coupled with vapor seal mastic in the mastic grooves, which provides superior resistance to air and moisture intrusion, allowing for increased thermal performance of the building envelope.

In new and retrofit construction, insulated metal panels function as walls, ceilings, and roofing for all types of architectural, commercial, and industrial applications. They are ideally suited for low- and mid-rise offices, convention centers, performing arts centers, arenas, airport terminals, schools and universities, religious facilities, and hospitals. Commercial and industrial applications include retail buildings, hangars, government facilities, equipment maintenance buildings, manufacturing facilities, warehouses, distribution centers, self-storage complexes, utility buildings, and controlled environment buildings where temperature control and insulation values are critical.



A "pre-manufactured perfect wall" using insulated metal panel systems is configured to function as environmental separation and combines the water, air, vapor, and thermal control in one layer.

PHYSICS OF INSULATED METAL PANELS

You can see in this graphic that an insulated metal panel system combines the water, air, vapor, and thermal control in one layer. The single component simplifies design, installation, performance, and warranties. The exterior cladding sheds most of the rain, the air cavity/drainage plane allows drainage and evaporation, and the barrier wall provides backup water protection and primary air, thermal, and moisture protection. This system replaces complicated multi-component assemblies used in traditional rainscreen construction, saving time and money.

With insulated metal panel systems the vapor profile is slightly altered from a site-built universal wall. Drying to the exterior occurs from the exterior face of the insulated metal panel system in all climate zones, while drying to the interior occurs from the interior face of the insulated metal panel system in all climate zones. Because the foam of the IMP has continuous contact with steel panel facings, interstitial condensation is eliminated.

Note the exterior face of the insulated metal panel system functions as the water control layer, air control layer, and vapor control layer. In addition, the interior face of the insulated metal panel system also functions as an air control layer and vapor control layer. This dual location of both an air control layer and vapor control layer allows the assembly to function successfully for refrigerated buildings and cold storage facilities in all climates.

The exterior face of the insulated metal panel system is so robust, and the rainwater control of the panel joints is so effective, traditional cladding is omitted in most applications. The exterior metal face of the panel system becomes the cladding; it provides protection from ultra-violet radiation and physical damage and typically satisfies aesthetic requirements. That being said, there are design options we will discuss at the end that allow the use of more traditional façade materials with insulated metal panels.

QUIZ

1. Which control layer is most important in terms of building envelope durability?
   a. Water control
   b. Air control
   c. Vapor control
   d. Thermal control

2. True or False: In the "perfect wall" the water, air, and vapor control layers are all located on the exterior of the structure, while thermal control is located outboard of the other control layers.

3. Which of the following is NOT one of the four functions of cladding?
   a. Protect the control layers from exposure to ultra-violet radiation
   b. Prevent insect infestation
   c. Reduce the rain load on the control layers
   d. Provide physical protection to the control layers
   e. Provide aesthetics

4. True or False: Continuity of the control layers is key to the hygrothermal performance of building enclosures.

5. True or False: Insulated metal panel (IMP) systems as a rainscreen barrier are a pre-manufactured version of a perfect wall.

6. Which of the following is a suitable application for IMPs?
   a. Low- and mid-rise offices
   b. Convention centers
   c. Hospitals
   d. Controlled environment buildings
   e. All of the above

7. True or False: An insulated metal panel system separates the water, air, vapor, and thermal control layers into 4 distinct layers.

8. True or False: Insulated metal panel systems, by virtue of their joint geometry, address thermal bridging in a more robust manner than site-built assemblies.

9. In commercial wall systems a minimum continuous _____ inch gap for all cladding systems is recommended, which is based more on construction tolerances than physics.
   a. 1/2
   b. 1/4
   c. 3/8

10. True or False: An HPCI barrier panel provides the benefits of insulated metal panels with more traditional facades.

This article continues on http://go.hw.net/AR616Course4. Go online to read the rest of the article and complete the corresponding quiz for credit.

SPONSOR INFORMATION

CODES AND INSULATED METAL PANELS

In some applications cavity insulation may need to be installed to improve acoustics. Cavity insulation affects the hygrothermal performance of the assembly under heating conditions in cold climates. The ratio of the thermal resistance of the insulated metal panel to the thermal resistance of the cavity insulation controls condensation.

The International Building Code (IBC) specifies this ratio for commercial and retail enclosures. Special use facilities with high internal moisture loads such as hospitals, museums, natatoriums, and data processing centers are excluded. In such facilities no cavity insulation should be installed; the thermal control layer should be located exterior to the structure and exterior to an air control and vapor control layer in all climate zones.

IECC Climate Zone	Minimum IMP/CI Ratio
Marine 4	0.2
5	0.35
6	0.5
7	0.7
8	0.95

Minimum ratio of the thermal resistance of IMPs to the thermal resistance of cavity insulation (CI) based on International Energy Conservation Code (IECC) climate zones.

The preceding table is adapted from the IBC and specifies the minimum ratio of the thermal resistance of insulated metal panels (IMP) to the thermal resistance of cavity insulation (CI) based on International Energy Conservation Code (IECC) climate zones and referenced by the IBC for commercial and retail enclosures.

For example, using this table, a commercial enclosure located in Chicago, IL (IECC Climate Zone 5) with cavity insulation of R-20, would require an IMP/CI ratio of 0.35. Taking 20 and multiplying by 0.35 yields 7.0. To control condensation in a commercial or retail enclosure in Chicago, the minimum thermal resistance of the insulated metal panel, as specified by the IBC, must be R-7.

IMP JOINT DESIGN IN HORIZONTAL AND VERTICAL WALL PANELS

Insulated metal panel joints are required to meet the same control requirements as field assembled systems and should provide water, air, vapor, and thermal control continuity. For example, the water control layer of a panel should be connected to the water control layer of adjacent panels via joint engagement and sealants.

In horizontal wall panels water control layer continuity is provided by a flashed and drained joint. The upward "tongue" of the lower panel functions similarly to the elevated vertical leg of a metal flashing. The exterior horizontal gap between upper and lower panels facilitates drainage at the panel joint.

Air and vapor control continuity is provided by sealant joints. Note insulated panel systems have both interior and exterior air control and vapor control layers, so they typically have both an interior and exterior seal. Thermal control continuity is provided by direct contact of the thermal control layers.

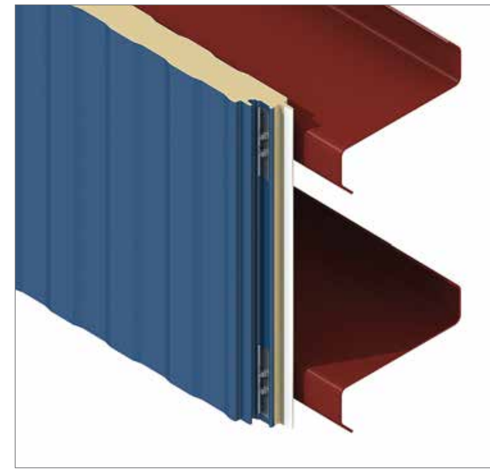
Moving on to vertical wall panel assembly joints, for vertical wall panel assemblies in low-rise applications and where wind driven rain loads are low, the exterior seal can be omitted. In cold climate applications and where wind driven rain loads are high, both interior and exterior seals are typically necessary.

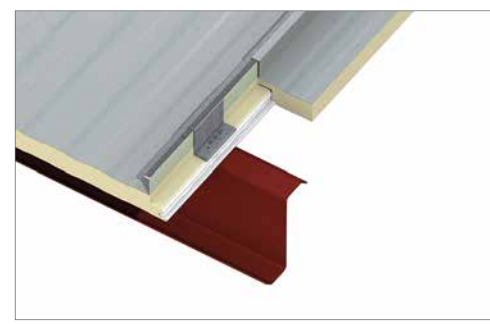
In refrigerated buildings and cold storage facilities the interior seal is typically omitted in warm and mixed climates to facilitate drying of the joint to the interior, as moisture drive is from warm to cold. In cold climates both exterior and interior seals are recommended.

Thermal control continuity is provided by direct contact between the thermal control layers of adjacent panels. The thermally conductive exterior and interior metal panel faces are broken at panel edges. The metal faces do not wrap continuously around panel edges thereby providing a thermal break.

IMPs MINIMIZE THERMAL BRIDGING

A key performance aspect of the site-built universal wall or perfect wall is the continuous insulation layer on the exterior of the structure. Attaching cladding systems through this thermal control layer to the structure behind it can result in thermal bridging at the attachment penetration points, degrading thermal performance. The two most common approaches to address this issue are to either limit direct continuous contact of the structural attachment using two layers of Z-bars installed perpendicular to each other or using clip angles to stand off/hold off structural attachment angles. Both of these approaches address the thermal bridging issue but nevertheless result in some degradation of thermal performance.





Insulated metal panels minimize thermal bridging because panel faces are separated by the thermal control layer and panel mounting clips are attached over the thermal control layer.

Insulated metal panel systems, by virtue of their joint geometry, address thermal bridging in a more robust manner than site-built assemblies. The panel mounting clips for both wall assemblies and roof assemblies are attached over the thermal control layer which acts as a thermal break.

IMPs AS RAINSCREEN SYSTEMS

The most important non-structural and non-fire performance aspect of any wall system is its ability to control rainwater which, as we know, is the function of the water control layer. In order for the water control layer to function properly, it must be able to resist the driving forces of rainwater which are able to access the surface of the water control layer.

The water control layer must resist hydrostatic and wind induced pressures. Hydrostatic pressure is pressure exerted by a liquid when it is at rest, due to gravity. Hydrostatic pressure from standing rainwater is typically greater than wind induced pressures. The best approach to address hydrostatic pressure is to prevent it from occurring or limiting its magnitude with proper drainage, especially at joint systems and panel terminations such as the base of a wall, framed openings, and transitions. Providing drainage is the most historically successful method of addressing hydrostatic pressure.

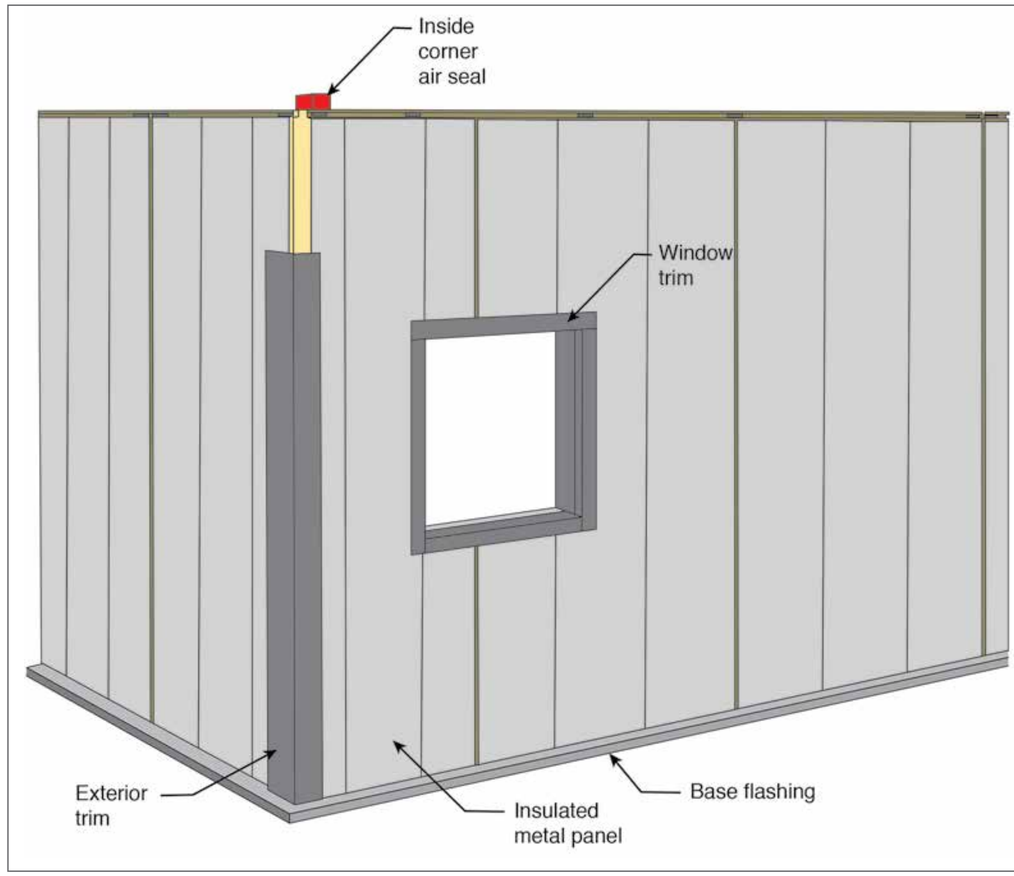
The solution to dealing with wind-driven water penetration is properly sealed barrier walls or rainscreen systems. Examples of barrier walls include insulated metal panels, concrete tilt-up, curtainwall, and storefronts. In rainscreen systems a water shedding layer over a drained and back ventilated water barrier is the most common defense.

Pressure equalized rainscreen (PER) systems are more complex and generally not effective for mitigating wind-induced air pressure for entire wall areas, but the concept is useful for joints and small volume airspaces such as those found at punched openings for windows, doors, storefront, and curtain wall connections. The concept of pressure equalization to control rainwater entry dates back a half century. Historically, it formed the basis of joint design in pre-cast panel systems and window-to-wall interfaces.

With face-clad insulated metal panel systems the key to addressing hydrostatic pressure is to drain the joints. The vertical drained joints, window trim elements, and corner trim elements provide continuity of the water control layer. The joint details specific to face-clad insulated metal panel systems were addressed earlier.

The most widely used method of controlling rainwater is claddings installed over insulated metal panel systems to provide a continuous water control layer, coupled with a continuous drained air gap over this water control layer. A continuous air gap as small as 1/32 inch is typical for drained hardcoat stucco systems and is provided by textured weather resistive barriers or building wraps, whereas an 1 inch air gap is typical behind brick veneers. This dimension is based on historic practice and is derived from "the thickness of a masons knuckles and fingers."

In commercial wall systems a minimum continuous 3/8 inch gap for all cladding systems is recommended, which is based more on construction tolerances than physics. The key word to note is "continuous." With brick veneers, stone veneers, and stucco, this continuous gap is accomplished with a drainage mat and filter fabric. With panel claddings, spacers and fastener systems provide a continuous gap.



With face-clad insulated metal panel systems the key to addressing hydrostatic pressure is to drain the joints. The vertical drained joints, window trim elements, and corner trim elements provide continuity of the water control layer.

PUNCHED OPENINGS

Windows and doors installed in wall openings are referred to as "punched" openings and have the same water, air, vapor, and thermal control requirements as panel joints, walls, or roofs. All control layers at punched openings must connect to the corresponding control layers of the panel system.

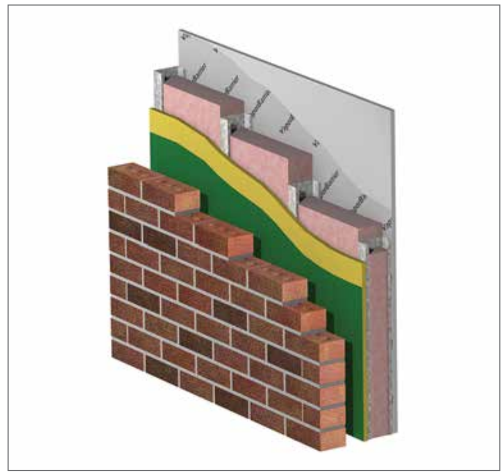
The water, air, vapor, and thermal control elements of a window or door should connect to the water, air, vapor, and thermal control element of adjacent panels. Membrane closure and sealants provide continuity of air, water, and vapor control layers, while insulation board provides thermal continuity. The membrane closure can be via a fully adhered membrane strip or a fluid applied flashing.

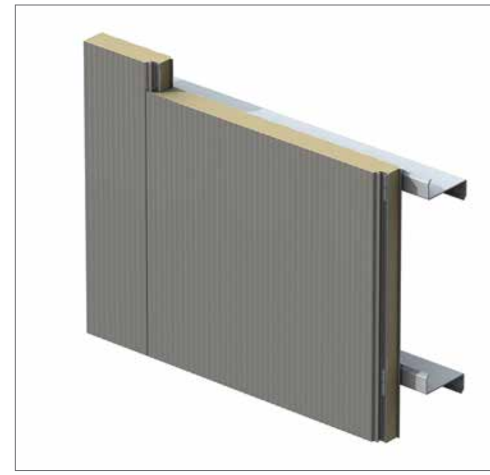
There should be interior and exterior sealant at the head of punched openings and only a single interior sealant at the jamb, which allows drainage to occur at the bottom of the window. This also allows air to enter the bottom of the window at the gap between the membrane closure and the bottom of the window unit. This air entry pressurizes the gap at the jambs and head, utilizing the principle of pressure equalization to limit the effect of wind induced air pressures.

CONTINUITY OF CONTROL LAYERS

As noted, continuity of the control layers is the key to hygrothermal performance of building enclosures. Roof to wall connections such as parapet assemblies need to be constructed such that the four control layers of the wall assembly connect to the four control layers of the roof assembly.

For a low parapet assembly the upper roof membrane extends over the top of the insulated metal panel assembly, while in a high parapet assembly the lower roof membrane extends over the top of the parapet framing. In high performance roof systems two membranes are typical—one above the thermal insulation and one below the thermal insulation. Both of these membranes need to be connected to the insulated metal panel assembly.





Built-up wall vs. IMP wall

Like roof-to-wall connections, foundation assemblies need to be constructed so that the respective control layers also connect to the wall assembly control layers. In foundation assemblies thermal bridging can be controlled by installing a "structural" thermal break such as rigid insulation under the steel framing.

RETROFITTING WITH IMPs

Insulated metal panels can be used to retrofit existing structures. Uninsulated mass assemblies can be over-clad with insulated metal panels, which act as the rain control layer and thermal control layer. A separate air and vapor control layer is installed directly on the exterior of the existing mass wall. The panels are installed over metal channels installed directly on the exterior of the structure and air and vapor control layer. The gap between the metal channels is filled with mineral wool that acts as an air convection suppressor.

COMPARISON OF INSULATED METAL PANELS WITH ALTERNATIVE SYSTEMS

Now let's compare insulated metal panel assemblies with the following alternative assemblies:

- Cavity insulated metal building and steel stud assemblies and externally insulated metal building and steel stud assemblies
- Blanket insulation purlin roof systems
- Face-sealed masonry block assemblies
- Cavity insulated wood frame assemblies and externally insulated/cavity insulated wood frame assemblies
- Uninsulated and insulated mass wall assemblies

CAVITY INSULATED AND EXTERNALLY INSULATED METAL BUILDING AND STEEL STUD ASSEMBLIES

The biggest issue with metal building and steel stud assemblies is thermal performance. These assemblies can be insulated externally, or internally within the metal building framing and steel stud cavities. The thermal performance of such assemblies is affected by two major issues, the conductivity of the steel framing/steel studs; and air leakage through and around improperly installed internal frame or cavity insulation.

When combined, both of these factors reduce the effective thermal resistance of the assembly by over 50 percent. The most effective manner to address these factors is to install continuous insulation on the exterior of the metal framing or steel studs and not install interior framing insulation or cavity insulation for thermal purposes. In such an approach, when interior framing insulation or cavity insulation is installed in conjunction with continuous external insulation, it provides an acoustical benefit rather than thermal benefit. From a thermal performance, externally insulated metal building and steel stud assemblies function similarly to insulated metal panel assemblies.

BLANKET INSULATION PURLIN ROOF SYSTEMS

Blanket insulation purlin roof systems have similar thermal conductivity issues that can be addressed by installing rigid insulation thermal breaks on the top of purlins. However, such thermal breaks do not address air leakage through and around blanket insulation when it is not installed in an airtight manner. The thermal performance of insulated blanket insulation systems does not provide comparable performance to insulated metal panel roof assemblies. Additionally, these systems are not suitable for refrigerated building assemblies because they cannot be made airtight from the top side.

FACE-SEALED MASONRY BLOCK ASSEMBLIES

Face-sealed masonry block assemblies can be internally insulated with a steel stud/cavity insulation or continuous rigid insulation approach. When steel stud cavity insulation assemblies are used they are subject to the same issues as cavity insulated metal building and steel stud assemblies discussed previously. In addition, they are limited to mixed climates and hot climates due to the impermeability of the exterior masonry blocks. These issues can be addressed by installing continuous impermeable rigid insulation directly to the interior of the exterior masonry block. Alternatively, closed cell medium density spray polyurethane foam insulation can be used. From a thermal perspective, when continuous impermeable rigid insulation or spray polyurethane foam are used, such assemblies function similarly to insulated metal panel assemblies.

CAVITY INSULATED WOOD FRAME ASSEMBLIES

Cavity insulated wood frame assemblies and externally insulated/cavity insulated wood frame assemblies do not have similar stud frame conductivity issues as those experienced by metal building and steel stud assemblies. However, they do face similar air leakage issues through and around improperly installed cavity insulation. These issues can be addressed by installing continuous external insulation, as is done with metal building and steel stud assemblies. The continuous external insulation reduces the temperature difference across the cavity insulation, reducing the effect of convection. Wood frame assemblies with continuous external insulation function similarly to insulated metal panel assemblies.

UNINSULATED AND EXTERNALLY INSULATED MASS WALL ASSEMBLIES

Now let's compare the thermal performance of uninsulated and externally insulated mass wall assemblies to insulated metal panel assemblies. A typical uninsulated mass wall is a concrete tilt-up panel. In hot-dry climates with consistent diurnal temperature swings (variation between a high and low temperature that occurs during the same day), an uninsulated heavy mass wall coupled with effective ventilation can approach the thermal performance of an insulated low mass wall such as an externally insulated steel frame system or insulated metal panel system. The key to this type of performance is effective coupling of the ventilation air to the mass, which facilitates getting thermal energy into and out of the mass on a daily cycle.

Additionally, the mass has to be sufficient to modulate the inward heat gain during the day and the outward heat loss at night—the thickness of the mass wall (thermal resistance) shifts the assembly's response of the inward daily heat flux approximately 6 hours. The hot-dry climate locations for this approach are very limited and not all hot-dry climates have consistent diurnal temperature swings. Accordingly, the model codes limit the use of uninsulated mass walls.

When the diurnal temperature swings are not consistent uninsulated mass walls function poorly. When the mass is holding thermal energy and the exterior temperature rises, significant conditioning energy is necessary for the enclosure to remain comfortable. In comparison, light mass assemblies are able to react quickly to conditioning energy. Accordingly, uninsulated mass wall assemblies are limited to hot-dry climates with consistent diurnal temperature swings.

Uninsulated mass walls are problematic in hot humid climates and mixed humid climates because the humidity of the outdoor air makes it difficult to use ventilation air for nighttime energy removal. Whole building ventilation must be controlled using enthalpy controls (less "energy" in the exterior air than interior air).

Uninsulated mass walls are also problematic in cold and severe cold climates. The interior surface of the mass wall stays below the comfort level because there is insufficient thermal energy available from the exterior, even with consistent diurnal swings.

The issues with uninsulated mass walls can be addressed with continuous exterior insulation. The key to effectively utilizing the thermal mass of externally insulated mass walls is coupling the mass to the interior space. This is difficult when interior linings such as stud wall framing with interior gypsum board enclose the mass.

Externally insulated mass walls enclosed with interior linings function similarly to insulated metal panel assemblies. Well insulated "light mass" assemblies perform similarly to insulated "heavy mass" assemblies with interior linings. Tilt-up concrete sandwich panels (rigid insulation cores encased in concrete) perform similarly to externally insulated mass walls. Note this is only the case where the insulation layer in the tilt-up concrete sandwich panels is continuous at panel-to-panel joints and intersections.

DESIGN OPTIONS FOR AESTHETICS—HPCI BARRIER PANELS AND STANDARD PANELS

A high performance continuous insulated (HPCI) barrier metal wall panel is an air, water, thermal, and vapor barrier panel that can be used as a back-up barrier behind any type of façade such as single skin architectural metal panels, brick, or stone. The panel is pre-insulated metal cladding. An HPCI barrier back-up panel is installed completely outside the structural supports, so there are no thermal bridges to reduce the energy efficiency of the wall. An HPCI Barrier is quick and easy to install and provides an economical solution to conventional air, water, thermal, and vapor control without sacrificing thermal efficiency. Such a system provides the benefits of insulated metal panels with a more traditional façade.

Unlike traditional back-up wall systems, the HPCI barrier is easily and quickly installed in a single step, which is more cost effective, eliminates the need for multiple work crews, minimizes construction debris, and reduces the likelihood of improper installation that could strike any stage of a traditional multi-layer scenario. Also, its high level of recycled content makes it a sound choice for architects, designers, builders, and contractors seeking an environmentally sustainable product.

DESIGN OPTIONS FOR STANDARD INSULATED METAL WALL PANELS

Standard insulated metal wall panels are available in different profiles, including striated, fluted, flat, and textured. The exterior face of a striated panel is lightly profiled with narrow longitudinal striations, providing a virtually flat appearance at a short distance. Other panels have a lightly corrugated profile on both faces of the panel, which ensures symmetry from outside the building to inside, and from room-to-room in partition applications. Such a panel is well suited for exterior wall and interior partition applications. A fluted insulated metal wall panel has a vertical ribbed profile that complements almost any commercial and industrial building. Other panels have an embossed stucco texture that mimics the look of conventional masonry stucco, or the look of finished precast concrete with the thermal efficiency of an insulated metal panel.

No matter what pattern is chosen, to ensure a lasting quality appearance, the exterior face sheet of all insulated metal panels are treated with a base primer, followed by a high quality coating.

SUMMARY

To summarize what we have learned today about insulated metal panels in comparison to perfect or universal walls, insulated metal panels:

- Are a type of perfect wall due to the location of their control layers.
- Are a truly universal wall and roof system and can be used in any climate zone.
- Can be used as a rainscreen barrier wall system.
- Consist of the same control layers as site built "perfect walls or roofs."
- Can be integrated with other wall and roof systems while still maintaining proper control layer continuity.
- Provide all four control layers with a single component.
- Do not require the use of supplemental air/water/vapor or thermal control layers.
- Can be used with supplemental cavity insulation subject to ratios listed in the International Building Code. ■