SECTION 10:
SIP Design BP 8: SIP Roof and Wall Assemblies

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SIPA
Structural Insulated Panel Association

SIP DESIGN-BP 8:

SIP Roof and Wall Assemblies

This document is created specifically for design professionals by the manufacturing members of the Structural Insulated Panel Association (SIPA). It dives deeper and provides more background into each of the summarized topics presented in the *Design with SIPs: DESIGN CONSIDERATIONS* overview which highlights important considerations during the design phase of a Structural Insulated Panel (SIP) structure. Decades of combined knowledge from SIPA manufacturers will help reduce the learning curve and leverage SIPs' exceptional qualities to achieve the high-performance results owners expect when building with SIPs. The considerations of how and why the best practices were developed as the common industry platform for SIP design are explored here.

The index below outlines ten topical areas, listed in sequence to match the order of design considerations and construction. The details in each chapter provide a deeper understanding of the subject matter to facilitate successful SIP design and later implementation. The current chapter is highlighted in blue.

1. High-Performance SIP Building Envelope
2. HVAC Systems with SIPs
3. SIP Structural Capabilities
4. SIP Sizes
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   - **8.2. Do not use low perm underlayments (i.e, ice and water shield) on a SIP roof with the exception of eaves and valleys.**
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   - **8.9. Obtain construction language from specification.**
   - **8.10. Consider PV (solar) array attachment to roof SIPs.**
   - **8.11. SIPs and Ridge Vents**
9. SIP Electrical
10. SIP Plumbing

SIP DESIGN-BP 8:

SIP Roof and Wall Assemblies

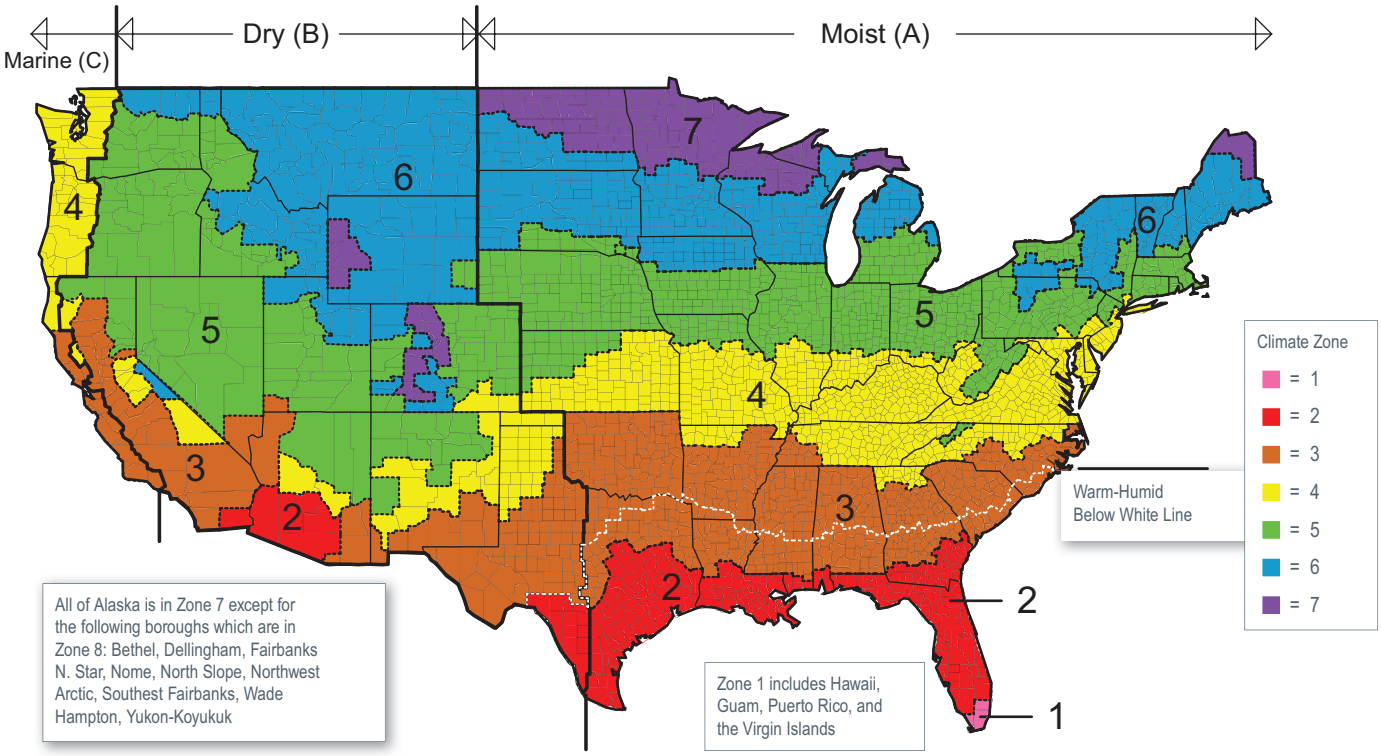
SIP DESIGN-BP 8.1:
Design for the appropriate climate zone to maximize durability.

Wall and roof connection joints are the weakest link of any building. It is no different when building with SIPs. It is important to understand in which climate zone the project you are designing will be built, to control air and moisture migration at panel joints for long-term durability. Depending on the location, the appropriate use and position of vapor retarder products like sealants, tapes and liquid applied barriers will change. Reference Figure 8.1 to understand the project's specific weather region and climate zone, which will dictate the proper building energy code and insulation requirements for your design.

Climate zones are determined by cooling/heating degree days, average temperatures and precipitation. In Figure 8.1, notice the white line across the southeast of the U.S., below which it is considered 'warm and humid' so SIP joint tape should go on the outside of the SIP. Refer to the next section, **SIP DESIGN-BP 8.2**, to determine which climate zone requires a vapor retarder to be applied to the interior facing of SIPs. By designing to the correct climate zone, you will be maximizing the durability of the SIP structure.

Additional helpful references are the Department of Energy's (DOE) *Building America Best Practices Series, Volume 7.3: Guide to Determining Climate Regions by County* and Joseph Lstiburek's *Builders Guide to Structural Insulated Panels (SIPs) for all Climates*.

FIGURE 8.1:
U.S. DEPT. OF ENERGY CLIMATE MAPS BY COUNTY



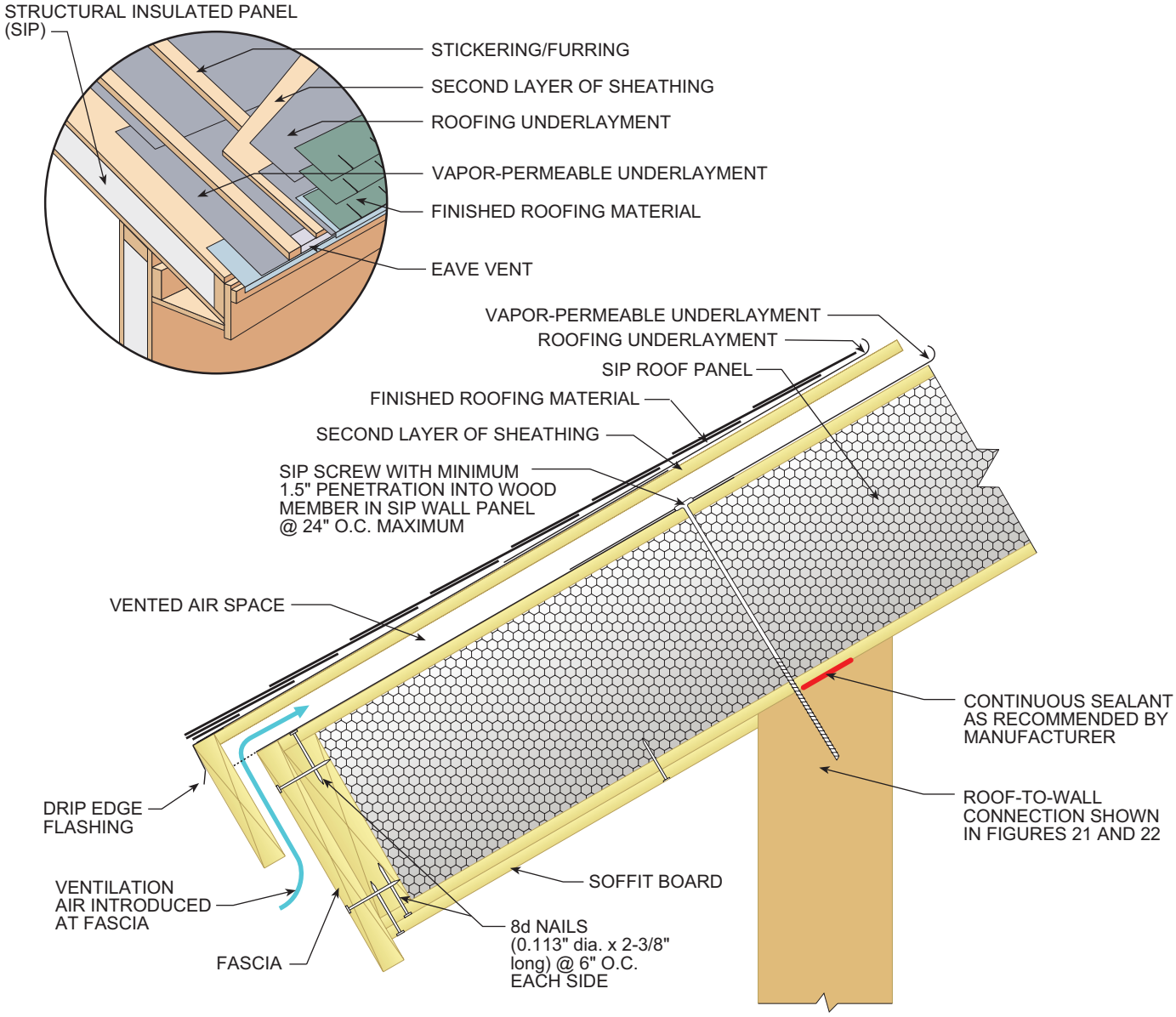
SIP DESIGN-BP 8.2:
Do not use low perm underlayments (i.e, ice and water shield) on a SIP roof with the exception of eaves and valleys.[1]

The long-term performance and durability of SIP roof assemblies is dependent on the assembly's ability to dry to the side to which it gets wet. SIPs have low permeability, which means that they cannot dry through the thickness of the SIP.

In situations that require the use of a self-adhered low-permeable underlayment over the entire roof, an additional layer of OSB must be installed over stickering/furring as a divorcement layer on the top side of the SIP roof. The self-adhered low-permeable underlayment should be installed on the exterior side of this second sheathing layer. A vapor-permeable underlayment needs to be installed on the exterior side of the SIP roof facer. Creating this air space, and also having eave and ridge venting between the exterior OSB facing of the SIP roof and the additional layer of OSB, is desirable. This condition is referred to as a cold roof. The detailing of the roof assembly using a cold roof assembly may mitigate ice damming due to radiant melting of the snow and provide an air space that will allow the OSB facing of the SIP roof to dry out should it get wet. (See Figure 27, reproduced on page 5, from *SIPs Basic Connection Details*, available for free download on the SIPA website, under Resources, Installation.)

SIP details of roof joints call for the use of sealant and SIP tape to mitigate air flow through the panel joints. The SIP tape is applied on the interior side of the panels in climate zones 5, 6, 7, 8. The use of SIP tape over the panel joints meets the building code requirements of a vapor retarder for the assembly. Consult the local building code for your project.

[1] This topic replaces Key Point 2 under SIP Roof and Wall Assemblies in the earlier document ***DESIGN CONSIDERATIONS***, which read "Do not provide complete coverage on the exterior of a vapor barrier such as peel and stick underlayment. Standard application of ice and water underlayment at eaves and valleys is acceptable over a SIP roof."



ALL SIP JOINTS SHALL BE AIR SEALED WITH SEALANT AND/OR SIP TAPE. FOLLOW SIP MANUFACTURER'S RECOMMENDATIONS FOR SIP TAPE WIDTHS AND SEALANT PATTERN AND THICKNESSES.

VERIFY NAIL SPACING PER MANUFACTURER SPECS/CODE LISTING

VENTED COLD ROOF GENERIC DETAIL

Fig. 27

from ***SIPs Basic Connection Details***.

If construction sequencing or detailing of the roof assembly does not allow for the use of SIP tape at the SIP joints, the use of a low-permeable underlayment over the surface of the SIPs is highly discouraged because of the low permeability of SIPs. Should moisture work its way between the OSB and a low-permeable membrane such as a 6-mil polyethylene sheeting, drying will not occur. The use of an air barrier on the underside of the SIPs may be warranted in these situations. Properly detailed and installed air barriers will reduce or eliminate air movement through the roof assembly, mitigating moisture issues due to air transport.

SIPA highly recommends that designers and builders consider detailing the roof assembly in a way which allows drying of the OSB to the side on which the OSB became wet.

Regardless of the roof cladding materials and underlayment used, they must meet all applicable code requirements to ensure that they protect the SIPs from direct exposure to moisture and still allow them to dry.

SIP DESIGN-BP 8.3:
Reservoir wall cladding (e.g., brick, stone, cementitious products, stucco, etc.) should have a rainscreen design that allows water to drain and air to circulate while increasing drying.

Structural insulated panels (SIPs), like all construction materials, are occasionally subjected to moisture exposure during the construction process. The construction process includes transportation of the SIPs to the jobsite, temporary storage prior to erection, and exposure to the elements prior to being protected with the appropriate wall or roof covering. Extensive testing by APA-The Engineered Wood Association has demonstrated that SIPs with OSB facers can withstand exposure to the elements during the construction process without significant loss in structural strength. (See SIPA Technical Bulletin 09: *Durability of SIPs Exposed to Moisture*).

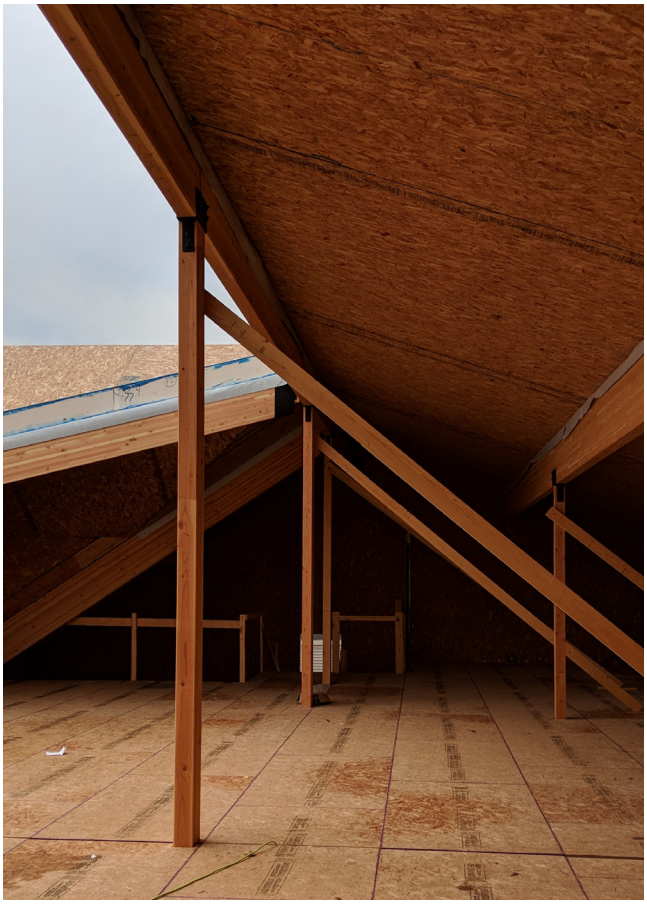
However, as with other wood-based products, long-term exposure of SIPs to moisture can result in structural degradation of the OSB. Therefore, it is imperative that the wall cladding system used with the SIPs – which may include metal siding, wood siding, stucco, masonry or others – provide drainage and air circulation between the SIP and cladding.

Many options are available to the design professional for siding applications. Special precautions need to be taken when reservoir claddings are used. Reservoir claddings are those which readily absorb water such as brick, stone, stucco, cementitious sheeting, wood, etc. Cladding such as these retain water and when beginning to dry (say from heat or sunshine) the water vaporizes and creates vapor pressure driving the moisture inward and into the wall assembly. Hence a rainscreen system is needed.

A rainscreen system consists of an exterior siding, an air gap created by stickering, a water resistive barrier (WRB layer), and the structural sheathing substrate which is OSB for SIPs. The function of the siding is to shed the large majority of the precipitation and to protect the WRB/substrate from UV degradation. Since the siding will not completely shed external moisture, it is imperative to provide drainage of any moisture that penetrates through the siding. The ventilated air gap made by furring between the siding and WRB in a rainscreen allows the moisture that penetrates or is absorbed by the siding from rain and dew to drain and evaporate quickly.

SIP DESIGN-BP 8.4:
A back-ventilated cladding may be appropriate for some climate zones and moisture regions.

As shown in Figure 8.1, climate zones are also divided into three moisture regions of Moist (A), Dry (B), and Marine (C). For example, the DOE's *Building America Best Practices Series, Volume 7.3: Guide to Determining Climate Regions by County* shows climate zone 4 has all three moisture regions.



In the Moist and Marine moisture regions, back-ventilated cladding or rainscreen (achieved by using a minimum 3/8-inch gap between cladding and housewrap) is highly recommended to be designed into the exterior cladding system, whereas in other areas it may not be necessary depending on annual precipitation.

Construction Instruction, *Building Science Corporation*, & Joseph Lstiburek's *Builders Guide to Structural Insulated Panels (SIPs) for all Climates*[2] are very good references to proper guidelines and design for rainscreens (aka exterior drainage planes) in different climate zones and moisture regions.

SIP DESIGN-BP 8.5:
Some claddings may require special fastening patterns for attachment to SIP facings.

The installation instructions of cladding manufacturers often require fastener embedment into the stud framing of the wall. SIPs may not have studs in the wall as required in light frame construction. The OSB facing is the material that provides the structural integrity for the attachment of wall and roof cladding systems.

Fastening of common exterior cladding materials into SIPs is achieved by following cladding manufacturers' instructions. Check with your cladding manufacturer and your SIP supplier for more information regarding the proper fastening of exterior siding to SIPs.

[2] See Chapter 2: *Rain, Drainage Planes and Flashings* and Chapter 10: *Assembly and Framing with SIPs.*

SIP DESIGN-BP 8.6:
Use code-approved underlayment and roof covering.

For SIP roof assemblies, a vapor-permeable underlayment should be installed on the exterior side of the roof panels. The higher the perm rating, the more 'breathable' the material is. This higher permeability allows the OSB to dry to the exterior should the OSB get wet during the life of the building. SIPs have low permeability, which means that they cannot dry through the thickness of the SIP.

As discussed in ***SIP DESIGN-BP 8.3***, structural insulated panels (SIPs) are occasionally subjected to moisture exposure during the construction process and can withstand this exposure to the elements without significant loss in structural strength. (See SIPA Technical Bulletin 09: *Durability of SIPs Exposed to Moisture*).

However, as with other wood products, long-term exposure to moisture can result in structural degradation of the SIP OSB facers. Therefore, it is imperative that the roof covering system used with the SIPs provide protection from long-term exposure to moisture. A wide variety of roof coverings such as asphalt shingles, metal roofing, clay tiles, built-up roofing and many other roof cladding materials can be used with SIPs. There are also many options for water-resistant roofing underlayment such as asphalt-saturated felt, rubberized asphalt and non-bitumen synthetics, which lie between the actual roof cladding and the SIP to provide a secondary layer of protection from the elements. Regardless of the roof cladding materials and underlayment used, they must meet all applicable code requirements to ensure that they protect the SIPs from direct exposure to moisture and still allow them to dry.

SIP DESIGN-BP 8.7:
Application of fully adhered products[3] to SIP roofs is not recommended. A separation layer is recommended to facilitate future roofing (cladding system) replacement.

For OSB durability reasons, as described above in ***SIP DESIGN-BP 8.2*** and ***8.6***, drying ability of the outer OSB layer is imperative both in low slope roof applications in which membrane is often applied and in steep slope roofs where ice and water shields are frequently used.

When a fully adhered, low slope roofing material is going to be installed on SIPs, the SIP roof must be separated from the adhered material by a divorcement layer placed over the SIP prior to the adhered roofing material. This separation layer (or divorcement material) can be a slip sheet on ballasted roof systems, a nailed base sheet for BUR (built-up roof) systems, a cover board such as gypsum or wood fiber with adhered membrane systems, or a field-installed second layer of OSB installed over sleepers on metal roofing systems or tile applications (i.e., cold roof). The separation layer will allow for the removal of the old roof cladding system and prevent damage to the top OSB facer of the SIP roof. SIPs require this protection since the OSB facing needs to remain intact to ensure structural performance is not compromised over the life of the building.

When membrane-adhered systems are to be attached to the divorcement layer applied over SIPs, it is recommended that the membrane material be attached with asphalt, pre-applied pressure-sensitive adhesives, or water-based adhesives. Solvent-based adhesives will cause deterioration to the core of the SIPs.

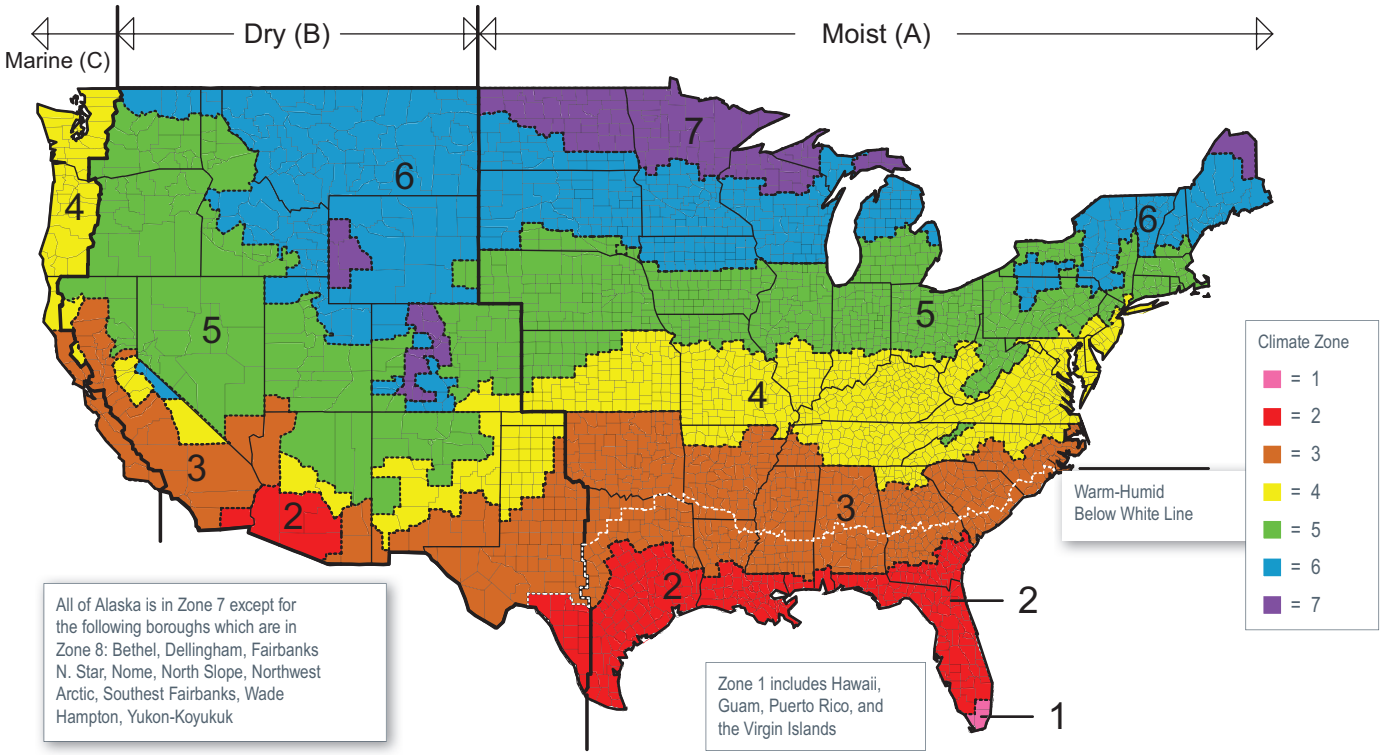
[3] Membrane roofing products such as TPO (thermoplastic polyolefin), EPDM (ethylene propylene diene monomer) and PVC (polyvinyl chloride)

SIP DESIGN-BP 8.8:

In climate zones Marine 4 and colder (climate zones 5, 6, 7 and 8), SIP tape should be installed on the interior of the structure.[4]

FIGURE 8.1:

U.S. DEPT. OF ENERGY CLIMATE MAPS BY COUNTY



The International Residential Code (IRC R702.7 - 2021) requires the following:

> "VAPOR RETARDERS
> Class I or II vapor retarders are required on the interior side of frame walls in Climate Zones 5, 6, 7, 8 and Marine 4."

The definition of vapor retarder class from the IRC is:

> "VAPOR RETARDER CLASS. A measure of the ability of a material or assembly to limit the amount of moisture that passes through that material or assembly. Vapor retarder class shall be defined using the desiccant method with Procedure A of ASTM E 96 as follows:
> Class I: 0.1 perm or less
> Class II: 0.1 < perm ≤ 1.0 perm
> Class III: 1.0 < perm ≤ 10 perm"

SIPs have a perm rating of 0.1[5]. Based on the IRC definition of vapor retarder class, SIPs meet the Class I definition of a vapor retarder. SIP joints must be constructed in a manner that achieves the same level of airtightness as the field area of the SIP.

Proper installation of SIPs requires that a sealant be installed when joining SIPs. The use of SIP tape over the SIP joints is also suggested depending on climate zone.

[4] This topic updates Key Point 8 under SIP Roof and Wall Assemblies in the earlier document ***DESIGN CONSIDERATIONS.***

[5] The 0.1 perm rating is based on proprietary test data of an entire 4.5-inch SIP assembly.

The SIP tape is formulated with a perm of less than 0.1. The combination of the SIPs and the SIP tape meets the building code requirements for vapor retarders.

SIP tape should be used at wall and roof SIP joints, SIP wall corners, ridge supports, midspan-supported SIP joints and valleys. Refer to manufacturer recommendations for SIP tape widths.

The use of an additional vapor retarder layer, such as polyethylene sheeting, should not be used with SIPs. This additional layer of vapor retarder material will inhibit the ability of the OSB facing to dry should it get wet.

SIP DESIGN-BP 8.9:
Obtain construction language from specification.

SIPA's *Guide Specification 06 12 00 for Structural Insulated Panels (SIPs)* is a great tool to use when designing and specifying assemblies for your project. It will walk you through the different steps of the project to create the best specification possible. You can also refer to SIPA's *Designing with SIPs: Design Considerations* available on the SIPA website.

SIP DESIGN-BP 8.10:
Consider PV (solar) array attachment to roof SIPs.

Solar Photovoltaic (PV) arrays may be attached to a SIP roof. The manufacturer of the solar panels and mounting racks will need to provide the weight (dead load) of the equipment being used. Along with the dead load of the panel, the design professional will need to consider the wind load, which is dependent on the geographic location of the project. When provided with this information, the design professional can determine how many and what type of fasteners are to be used.

The location of the PV array and mounts needs to be clearly defined on the plans. Details of the PV array mounts are also required. The SIP manufacturer along with the design professional will determine if additional support is needed and what connection details are required in the SIP roof.

SIP DESIGN-BP 8.11:
SIPs and Ridge Vents.[6]

A ridge vent is an air exhaust vent installed on the peak of a roof. When installing a ridge vent in a conventionally framed attic, an air slot is cut in the roof deck along the roof's peak. This air slot is then covered by the ridge vent. Ridge vents help to provide continuous, uniform exhaust ventilation at the highest portion of the attic and are designed to resist wind-driven rain and snow, as well as insect and debris infiltration. Ridge cap shingles are typically installed over the ridge vent to protect the vent and provide a clean finished look on the roof.

In SIP construction, when SIPs are used as the roofing system, an attic space is not created. An attic, as defined by the IRC, is the unfinished space between the ceiling assembly and roof assembly. In

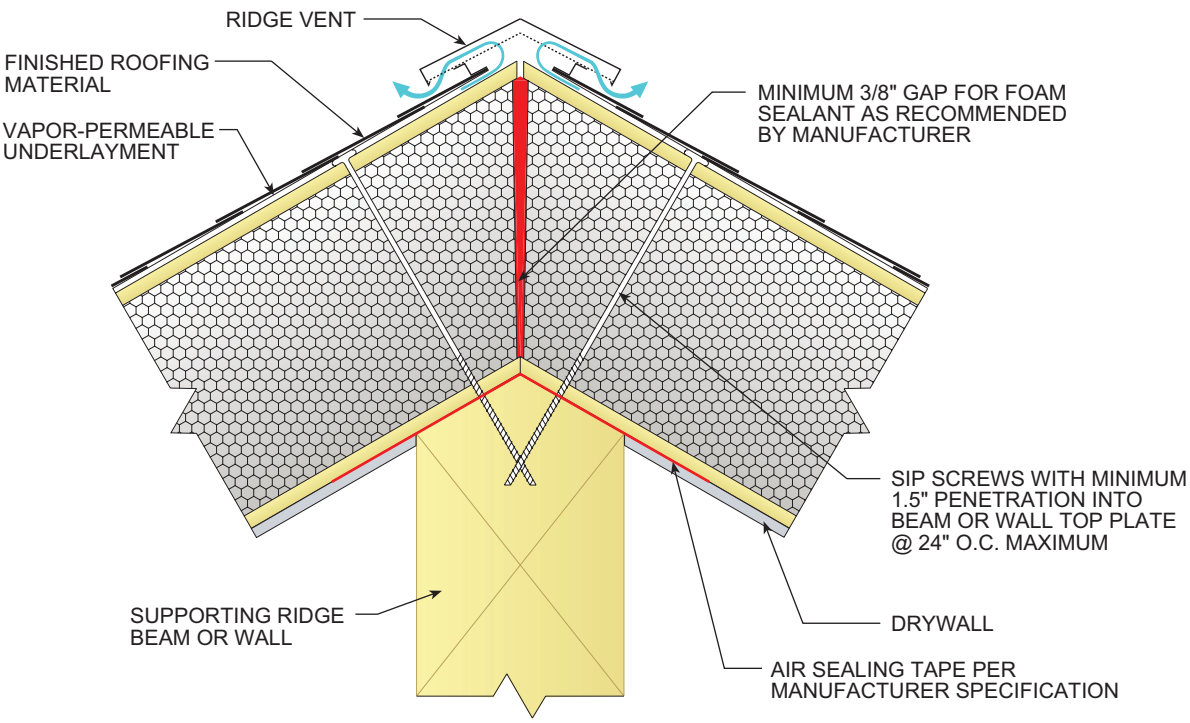
[6] This topic is an addition to those listed in the earlier document ***DESIGN CONSIDERATIONS.***

conventional construction there is an insulated ceiling assembly and an uninsulated roof deck assembly. The space between these two assemblies is what the IRC defines as an attic. With SIPs, the roof assembly is the insulated assembly and is typically the external envelope of the structure. The space above a flat ceiling is within the conditioned space.

SIP roof assemblies can benefit from the use of ridge vents. The use of breathable, high perm underlayments are strongly recommended in SIP roof assemblies. Due to the nature of a SIP, the OSB facers are only able to dry to the side they are on. The use of a high perm, breathable underlayment allows moist air from the environment to work its way away from the OSB, through the breathable underlayment, and up toward the ridge. The ridge vent along the peak of the roof provides an exit route for this moist air. The major difference in installing a ridge vent in a SIP roof assembly is that no slots are cut in the roof SIPs OSB along the ridge. The ridge vent is installed over the breathable roofing underlayment at the ridge, providing the exit path for moist air that is under the roof covering.

FIGURE 8.2

ROOF-TO-ROOF PANEL CONNECTIONS: SIP WITH RIDGE VENT



ALL SIP JOINTS SHALL BE AIR SEALED WITH SEALANT AND/OR SIP TAPE. FOLLOW SIP MANUFACTURER'S RECOMMENDATIONS FOR SIP TAPE WIDTHS AND SEALANT PATTERN AND THICKNESSES.

VERIFY NAIL SPACING PER MANUFACTURER SPECS/CODE LISTING

Fig. 18a from ***SIPs Basic Connection Details***.

Glossary of Terms

APA: APA – the Engineered Wood Association (www.apawood.org) is a nonprofit trade association helping the industry create structural wood products of exceptional strength, versatility and reliability.

Attic: the unfinished space between the ceiling assembly and roof assembly.

Attic, habitable: a finished or unfinished habitable space within an attic.

Back-ventilated cladding: a ventilated or pressure moderated air space immediately behind the exterior cladding to control entry of rain moisture by air pressure differences by reducing those air pressure differences and providing moisture removal (see "Stickering").

Cold roof: a vented roof in any hygro-thermal zone.

Divorcement layer: separation material between exterior OSB of SIP roof panel and roofing membrane.

IRC: International Residential Code. The IRC addresses the design and construction of one- and two-family dwellings and townhouses not more than three stories above grade, establishing model code regulations that safeguard the public health and safety in all communities, large and small.

Low slope: any roof with a slope less than 3/12 pitch.

Peel and stick: generic term used for low perm self-adhering roofing underlayment.

Rainscreen: an exterior wall detail where the siding (wall cladding) stands off from the moisture-resistant surface of an air/water barrier applied to the sheathing to create a capillary break and to allow drainage and evaporation. The *rainscreen* is the cladding or siding itself but the term rainscreen implies a system of building. Ideally the rainscreen prevents the wall air/water barrier from getting wet but because of cladding attachments and penetrations (such as windows and doors) water is likely to reach this point, and hence materials are selected to be moisture tolerant and integrated with flashing. In some cases a rainscreen wall is called a *pressure-equalized rainscreen* wall where the ventilation openings are large enough for the air pressure to nearly equalize on both sides of the rain screen, but this name has been criticized as being redundant and is only useful to scientists and engineers.

Reservoir Wall Cladding: a cladding that absorbs and stores moisture, such as brick, stone, wood, non-synthetic stucco and fiber cement.

Ridge Vent: an air exhaust vent installed on the peak of a roof.

Roof Covering: any system covering a roof.

SIP tape: an all-weather vapor-tight joint sealing tape developed for SIPs and other high-performance building envelopes.

Steep slope: any roof with a slope of 3/12 pitch or greater.

Stickering: also known as furring strips, sleepers, slats or stickers, these are strips of material inserted between layers to provide air flow and permit drying.

UV Degradation: the cracking or disintegration of materials exposed to ultraviolet radiation, most commonly due to sunlight exposure.

Water-Resistive Barrier (WRB): thin membrane intended to resist water which penetrated behind the exterior cladding; also referred to as a drainage plane.

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