STRUCTURAL INSULATED PANELS (SIPs)

Best Practices

A compendium guide for everything you need to know to get started with SIPs.

ACMEPANEL

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SIPA
Structural Insulated Panel Association

BEST PRACTICES GUIDE

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SECTION 1:
Designing with SIPs
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DESIGN CONSIDERATIONS

This document was created specifically for design professionals by the manufacturing members of the Structural Insulated Panel Association (SIPA). It 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 content provides a common industry platform for SIP design. SIPA hopes to make your design role easier and more efficient.

Beaver Island Brewing Co., St. Cloud MN

High-performance building envelopes use SIPs

SIPs yield high-performance building envelopes with energy performance well beyond conventional framing. SIPs provide a core of high R-value solid insulation typically requiring no additional continuous insulation on the building exterior. Elimination of traditional batt or spray insulations eradicates the installation quality challenges these products create and removes the need for insulation subcontractors. The large size of SIPs results in fewer air gaps, reduced thermal bridging from fewer lumber connections (lower framing factor) and elimination of air spaces within the wall cavity. SIPs provide a virtually airtight envelope improving indoor air quality (IAQ) and creating healthier homes and businesses. Airtightness also reduces HVAC sizing and dramatically improves occupant comfort by providing consistent room temperatures, regardless of the number of floors. A SIP's thickness determines its insulation R-value, but the greatest gain comes from the tightness of the engineered design and the other high-performance components (HVAC, windows, etc.) specified by the designer.

SIP performance is based on more than its stated R-value

R-values of SIPs are readily available from SIP manufacturers. These are useful insulation metrics but only one component in the evaluation of a high-performance building envelope. Integration of all system components and airtightness of the envelope assembly are more important considerations for designers seeking performance over individual component metrics. To illustrate this, the Department of Energy's Oak Ridge National Laboratory (ORNL) tested the performance of large section wall assemblies. The resulting whole-wall R-value data revealed that a 4-inch SIP wall rated at R-14 outperformed a 2 x 6-inch wall with R-19 fiberglass insulation. The whole-wall R-value was R-21 for a 6-inch SIP wall or 96 percent higher than the whole-wall R-value of R-11 for the 2 x 6-inch wall using theoretically R-19 fiberglass insulation. ORNL also tested a SIP structure side by side with a conventional 2 x 4 structure to evaluate air leakage. The SIP structure had only 7 percent the air leakage of the conventional structure. In short, unlike for SIPs, joining real-world air-leakage rates and thermal bridging for conventionally framed structures lowers performance far below their theoretically calculated effective insulation R-values. For more information relating to key high-performance building envelope metrics, visit the technical drop-down menu at www.sips.org.

Skokomish Community Center, Shelton WA

Rocky Mountain Institute Innovation Center, Basalt CO

HVAC system rightsizing reduces costs and enhances comfort and performance

SIP envelopes deliver a high-performance, virtually airtight shell. Because of this, the building must have mechanical make-up air. Several options introduce fresh air with varying degrees of complexity and cost. To ensure a balanced HVAC system, consider specifying a Heat Recovery Ventilator (HRV) or Energy Recovery Ventilator (ERV). Superior SIP energy efficiency and airtightness reduce HVAC equipment load and often provide savings via smaller unit requirements. Design should also include HVAC installed inside the conditioned SIP envelope. Conventional practice cannot be used in sizing HVAC equipment for SIP structures. Oversized equipment is not only more costly but cycles on and off frequently for short durations which inhibits the building's ability to dehumidify properly leading to comfort and mold concerns. SIP building designers, HERS raters and HVAC professionals can accurately calculate thermal performance of SIP envelopes using energy modeling with ACCA Manual J or REM/Rate or Ekotrope design software. Actual air leakage performance is best determined by a pre-drywall blower door test. SIP structures typically achieve less than 2.0 air changes per hour (ACH) @50Pa at this stage, but values less than 1.0 ACH50 are often achieved with proper design and installation. While SIPs provide the basis for an airtight structure, overall performance can be compromised if proper consideration for energy load calculation inputs or installation is not given to the other critical system components (e.g. windows, HVAC, plumbing, etc.,).

Kenmore Town Green Community Center, Kenmore WA

SIP structural capabilities cater well to virtually any design

SIP structural capacities comply with building codes through evaluation reports from third-party evaluators including ICC-ES, ICC NTA, Intertek and IAPMO. SIP increased strength over conventional framing enables greater design flexibility. A SIP can span up to 24 feet when incorporating structural connections (splines), eliminating intermediate support structures and creating spectacular vaulted ceilings. Many designs eliminate headers with conscious awareness of where point loads are located, reducing costs, labor and thermal breaks. SIP manufacturers publish charts to determine load capacities and work with designers ensuring code conformance. SIPA manufacturing members are an invaluable resource; each provides understanding on how SIP height, thickness and connection methods affect the structure's design. Manufacturers can provide lists of structural engineers experienced with SIPs.

Lake Chelan Building Supply, Chelan WA

SIPs are typically factory cut for accuracy, quality and reduced onsite labor

The cost and scarcity of construction labor is a challenge; the more that can be done by the SIP manufacturer, the less demand for what has become a scarce resource – jobsite labor. Because SIPs are manufactured in very large sizes (up to 8 x 24 feet), there are fewer connections, resulting in faster installations and a much tighter envelope. Working with SIPA manufacturers, designers can reduce costs by employing common SIP dimensional sizes of 4', 8', 12', 16', etc. in their designs. Factory lumber installations minimize jobsite labor while ensuring joint and boundary connection quality.

SIPs are manufactured using "SIP shop (or panelized) drawings"

SIPA manufacturers convert architectural drawings into SIP shop drawings. Shop drawings specify SIP size, layout, assembly details and installation specifications. They are also used for factory fabrication purposes. Shop drawings are provided to the client, or their authorized representative, for review and approval. Commitment to the drawing review process is crucial. Attention to detail during review ensures fabricated panel accuracy, installation ease and meeting SIP performance expectations. Early interaction with the SIP manufacturer helps design optimization resulting in material cost savings and installation speed. SIPA manufacturers can share samples of SIP shop drawings for your review and understanding.

Living Word Bible Camp, Grand Rapids MN

SIPs are customized to varying levels depending on client needs

SIPA manufacturers offer differing levels of SIP fabrication. They include blank SIPs, prefabricated SIPs and ready-to-assemble (RTA) packages.

BLANK SIPs are the least expensive, but limit your installation speed advantage, create additional waste, and require a higher degree of installation skill as all cutting is performed onsite.

PREFABRICATED SIPs are designed and cut in the factory increasing site installation speed, improving fit and finish.

RTA packages include factory preinstalled internal lumber and headers, maximizing onsite speed and efficiency.

Prefabrication orders are typical, although as labor becomes scarce RTA packages are gaining in popularity. SIPA manufacturers can provide detail concerning benefits of each option.

Roof and wall assemblies

SIPs are compatible with conventional roof and wall claddings. Unlike traditional framing, there is no internal air cavity within the SIP. The foam core of SIPs is solid and continuous throughout the wall and roof, eliminating convection and condensation issues occurring in conventional cavities. It is important to ensure a code-approved weather-resistive barrier is specified under wall claddings and approved underlayments for roof covering. Designing for the appropriate climate zone will help maximize durability. In some climate zones, a back-ventilated assembly may be appropriate. Because SIPs use very little solid lumber, an increased fastener schedule could be required when attaching exterior cladding. Application of fully adhered products to SIP roofs is not recommended. A separation layer should be added between the SIP roof and underlayment to avoid damage to the exterior SIP facing should there be a need to remove and replace the underlayment in the future.

Camp Ronald McDonald, Mountain Center CA

Factory cut electrical chases reduce electrician time in the field

Electrical chases are typically provided by SIPA manufacturers, simplifying electrical rough-in and saving electrician labor by eliminating time spent drilling holes in studs. Vertical and horizontal chases are provided in SIP walls to assist with wiring. Standard practice is to cut chases horizontally at outlet and switch heights. Chases can be added to SIP roofs upon request. Use of surface mounted LED lighting is recommended in place of recessed lighting as it doesn't penetrate the envelope and jeopardize airtightness. Determining electrical requirements prior to SIP manufacturing reduces the inefficiency of field installation. Plan a shop drawing review with the electrician prior to final approvals to verify chase locations, accommodate electrical layout and ensure code compliance.

Sail Newport, Newport RI

Design plumbing into interior walls

Eliminating the possibility of condensation or supply lines freezing within a SIP wall is an important design consideration. Plumbing should be relocated to interior walls wherever possible. If plumbing must be located on an exterior wall, it is recommended that an external chase be installed on the interior side of the SIP wall to conceal plumbing. Plumbing penetrations such as drain waste vent pipes can be placed perpendicularly through SIPs if thoroughly sealed to prevent air infiltration. Consult with a SIPA manufacturer if this is necessary.

To better understand the science of building with SIPs

Review *Builder's Guide to Structural Insulated Panels (SIPs)* by Joseph Lstiburek. This resource provides invaluable assistance in Building Science related details and can be purchased online at Amazon or www.sips.org.

South Dakota Pheasant Acres, Armour SD

Designing with SIPs:
CHECKLIST

The Structural Insulated Panel Association (SIPA) provides this checklist sharing the manufacturing membership's decades of combined knowledge to ensure the best experience and outcome for designers, builders, and owners of structural insulated panel (SIP) buildings. SIPA hopes to make your design-role easier and more efficient.

CHECKLIST

High-Performance SIP Building Envelope

SIPs are used to design high-performance building envelopes offering energy performance beyond conventional framing.

KEY POINTS:

- ☐ 1. SIPs meet and exceed building code thermal envelope requirements and eliminate additional continuous insulation needs on the building exterior.
- ☐ 2. SIPs provide extremely airtight structures, a key component improving indoor air quality (IAQ).
- ☐ 3. SIPs are available in a range of thicknesses delivering exceptional thermal performance.
- ☐ 4. Various SIP connections are available which minimize thermal bridging, lower installation costs, and install and seal with ease.
- ☐ 5. Factory applied rigid foam insulation cores eliminate concerns over quality insulation installation (QII).
- ☐ 6. Reduced HVAC requirements.

ACTION ITEM:

- ☐ Contact a SIPA manufacturing member at www.sips.org to learn about the benefits of SIP construction.

CHECKLIST

HVAC Systems with SIPs

SIP envelopes deliver high-performance, extremely airtight envelopes. The energy efficiency and tightness positively affect the HVAC design resulting in smaller unit requirements.

KEY POINTS:

- ☐ 1. Oversizing equipment jeopardizes building and equipment durability while needlessly increasing expenses.
- ☐ 2. SIP building designers, HERS raters and HVAC professionals must accurately calculate thermal performance of SIP envelopes.
- ☐ 3. An energy model using ACCA Manual J or REM/Design software should be used to verify proper equipment sizing.
- ☐ 4. Airtightness: Actual performance is best determined by a pre-drywall blower door test. A pre-construction estimate of less than 2 ACH is appropriate, and it is common to achieve less than 1 ACH50. Airtightness can be compromised if similar attention is not given to the other system components (e.g. windows, HVAC, plumbing, etc.).
- ☐ 5. Understand the R-value of the SIP provided. SIP R-value changes with thickness and R-values increase when temperatures drop. Code-required R-values are provided at 75˚F, but additional information is available at colder temperatures.
- ☐ 6. High-performance structures designed and built extremely airtight must have make-up air. There are several options with varying degrees of complexity and cost ensuring an HVAC system that will introduce fresh air.
- ☐ 7. Penetrations in the SIP envelope should be sealed to maximize airtightness.

ACTION ITEMS:

- ☐ 1. Work with an HVAC professional who is familiar with high-performing, extremely airtight structures.
- ☐ 2. Keep all HVAC equipment and duct work inside the conditioned SIP envelope.
- ☐ 3. Use energy calculations reflecting proper SIP foam core long-term thermal R-values along with the energy efficiency and the extreme airtightness of the SIP envelope to avoid HVAC equipment oversizing.
- ☐ 4. Consider specifying a heat recovery ventilator (HRV) or energy recovery ventilator (ERV), as referenced in ASHRAE 62.2 guidelines, for balanced fresh make-up air.

CHECKLIST

SIP Structural Capabilities

SIPs have the structural strength to work well in virtually any design.

KEY POINTS:

- ☐ 1. Manufacturers publish construction manuals and load design charts that can be accessed to understand structural capacities.
- ☐ 2. SIPs have been included in the IRC since the 2007 supplement to the 2006 IRC.
- ☐ 3. Structural capacities are recognized for compliance with Model Building Codes in evaluation reports from ICC-ES, ICC NTA, Intertek or IAPMO.
- ☐ 4. The structural capacity of SIPs changes with height/length, thickness and connection method.
- ☐ 5. SIP roofs offer great design flexibility to span long distances. SIPs can be combined with structural splines to span up to 24 feet. Exterior walls, beams, purlins, interior partitions, timber frame, or trusses constructed of either wood or steel are required to support a SIP roof.
- ☐ 6. SIPs are compatible with internal conventional framing.
- ☐ 7. Point loads may dictate the need for additional structural components to be embedded internally. Avoid point loads over openings to allow SIPs to act as the header without the need for additional structural elements.
- ☐ 8. SIP roofs can cantilever past walls to provide overhangs.
- ☐ 9. SIPs can act as their own header minimizing costs and maximizing thermal performance.
- ☐ 10. Wall SIPs may require a cap plate to meet high point load conditions.

ACTION ITEMS:

- ☐ 1. Contact a SIPA manufacturing member at www.sips.org to request their structural information and evaluation report.
- ☐ 2. Engage your SIP manufacturer early in the design to minimize structural redundancy and to provide a list of structural engineers experienced with SIPs.

CHECKLIST

SIP Sizes

SIPs can be manufactured in very large sizes (up to 8 x 24 feet). Large monolithic SIPs provide faster installation and reduce the number of connections which results in a much tighter envelope.

KEY POINTS:

- ☐ 1. Use support spacings of 4’, 8’, 12’, 16’, etc. to maximize efficiency of SIP layout and to reduce costs.
- ☐ 2. SIP roofs are supported by structural elements, either parallel or perpendicular to the ridge. Orientation is a function of the support elements and the spacing.
- ☐ 3. SIPs provide for long spans which may eliminate some conventional roof supports.
- ☐ 4. Wall thickness will generally increase when using SIPs over conventional construction. Extension jambs may be required for window and door detailing.

ACTION ITEMS:

- ☐ 1. Contact a SIPA manufacturing member at www.sips.org to learn about their SIP size capabilities.
- ☐ 2. Use SIPA manufacturer load design charts to verify maximum span for design conditions.

CHECKLIST

SIP Shop Drawings

SIP manufacturers typically convert architectural drawings into SIP shop drawings. Shop drawings specify SIP size, layout, assembly details and installation specifications. They are also used by the SIP manufacturer for accurate CNC fabrication.

KEY POINTS:

- ☐ 1. Depending on complexity of design, need for engineering, permitting, and possible revisions, the development of SIP shop drawings is a process that relies on engagement from those reviewing these drawings on behalf of the building owner.
- ☐ 2. SIP shop drawings are provided for client review and approval.
- ☐ 3. Let the SIP manufacturer do the work of establishing initial SIP layout and associated details.
- ☐ 4. Both SIP wall skins (inner and outer facings) must fully bear on the support deck without any overhang. Detail accordingly.

ACTION ITEMS:

- ☐ 1. Contact a SIPA manufacturing member at www.sips.org and ask for a sample SIP shop drawing for your review and understanding.
- ☐ 2. Involve the SIPA manufacturer early to ensure SIP design optimization. Minor alterations can provide dramatic savings in material costs and speed of installation.

CHECKLIST

SIP Fabrication/Manufacturing

Different levels of SIP fabrication are offered by SIP manufacturers. They include blank SIPs, prefabricated SIPs, and ready to assembly (RTA) packages.

KEY POINTS:

- ☐ 1. Blank SIPs are the least expensive, but limit your speed of installation advantage, create additional onsite waste, and require a higher degree of installation skill as all cutting is performed onsite.
- ☐ 2. Prefabricated SIPs are designed and cut in the factory to increase speed of installation and improved fit and finish on the jobsite.
- ☐ 3. An RTA package includes internal lumber and headers provided and preinstalled in the factory to maximize speed and efficiency onsite.

ACTION ITEM:

- ☐ Contact a SIPA manufacturing member at www.sips.org to learn about their SIP fabrication capabilities.

CHECKLIST

SIP Installation

SIPs are high-performance building envelopes and use of an experienced SIP installer is strongly recommended.

KEY POINTS:

☐ 1. Training programs are available to installers, ensuring that an educated installer understands the importance of proper installing and sealing of the SIP package. Programs include:

- SIPA online training course
- SIPA Registered Master Builder & Designer programs
- SIPschool hands-on field training
- Carpenters International Training Fund (CITF) for SIPs
- SIP manufacturer in-house training programs

☐ 2. Home energy raters verify building air leakage performance with blower door tests and can be found through the RESNET website at www.resnet.us.

ACTION ITEMS:

☐ 1. Mandate experienced SIP installers be used for the SIP erection. Contact SIPA at www.sips.org to find experienced SIP installers.

☐ 2. Specify a HERS rater to perform a blower door test to verify a high-performance envelope was obtained.

CHECKLIST

SIP Roof and Wall Assemblies

SIPs are compatible with conventional roof and wall claddings. As with all high-performance building envelopes, proper detailing is critical.

KEY POINTS:

- ☐ 1. Design for the appropriate climate zone to maximize durability.
- ☐ 2. Do not use low perm underlayments (i.e., ice and water shield) on a SIP roof with the exception of eaves and valleys.
- ☐ 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.
- ☐ 4. A back-ventilated cladding may be appropriate for some climate zones and moisture regions.
- ☐ 5. Some claddings may require special fastening patterns for attachment to SIP facings.
- ☐ 6. Use code-approved underlayment and roof covering.
- ☐ 7. Application of fully adhered products to SIP roofs is not recommended. A separation layer is recommended to facilitate future roofing (cladding systems) replacement.
- ☐ 8. In climate zones 4 and colder, SIP Tape should be installed on the interior of the structure.
- ☐ 9. Obtain construction language from specification.
- ☐ 10. Consider PV (solar) array attachment to roof SIPs.
- ☐ 11. SIPS and Ridge Vents - SIP roof assemblies can benefit from the use of ridge vents.

ACTION ITEMS:

- ☐ 1. Review *Builder's Guide to Structural Insulated Panels (SIPs)* by Joseph Lstiburek. This resource provides invaluable assistance in Building Science related details and can be purchased online at Amazon or at www.sips.org.
- ☐ 2. Verify manufacturer recommended sealing of SIP joints is completed prior to installation of cladding.
- ☐ 3. Use code-approved weather-resistive barrier under cladding for walls.
- ☐ 4. Follow cladding manufacturer's recommendations for fastening to SIPs. If not available, review fastener capacities of OSB to determine fastening schedule.
- ☐ 5. Provide specific instructions to the wall cladding and roofing trades. This input should be consistent with the detailing needed for the climate and type of cladding.

CHECKLIST

SIP Electrical

Electrical chases are typically provided by the SIP manufacturer to simplify the electrical rough-in, saving the electrician a great deal of time in the field.

KEY POINTS:

- ☐ 1. Vertical and horizontal chases are provided in SIP walls assisting with wiring at outlet and switch heights.
- ☐ 2. Wall and roof chases can be added or removed, prior to SIP manufacture. Shop drawings confirm all chase locations to avoid unnecessary cutting of SIPs in the field. Pre-planning for installation and special chase locations is critical.
- ☐ 3. Electrical chases should be sealed after electrical rough-in inspection to maximize airtightness.
- ☐ 4. An experienced SIP installer is your best insurance that the electrical rough-in will go smoothly.
- ☐ 5. Recessed lights are not recommended for installation in SIP roofs. Use of surface mounted LED lighting is recommended.

ACTION ITEMS:

- ☐ 1. Plan a review of the shop drawings with the electrician to verify chase locations to accommodate electrical layout and code compliance.
- ☐ 2. Consult with your SIP manufacturer concerning electrical chases in roofs.

CHECKLIST

SIP Plumbing

Plumbing should be placed within interior walls to protect the integrity of the high-performance envelope and to avoid the freezing of the supply lines in cold climates.

KEY POINTS:

- ☐ 1. Plumbing is recommended to be placed in interior walls to provide for an optimal exterior building envelope.
- ☐ 2. Minimize roof penetrations and consider consolidating all vents away from south facing roof planes for potential solar array.

ACTION ITEM:

- ☐ If plumbing needs to be placed in exterior walls, consult with SIP manufacturer.

Blue Wave on the Bay, Ashland WI

Blue Wave on the Bay, Ashland WI

Discover how easily you can start or deepen your understanding of designing, installing, and excelling with SIPs in your next commercial or residential project with the decades of industry learnings, tips, and resources at your fingertips:

- SIP Industry AIA/MasterSpec Specification
- Designing with SIPs: Design Considerations
- Building with SIPs: Need to Know
- SIP Design & Builder Best Practices Deeper Dives
- Technical Bulletins
- *Builder's Guide to Structural Insulated Panels (SIPs)* by Joseph Lstiburek of Building Science Corporation
- Building Education with SIPs Training (BEST) Videos and Certification
- AIA Continuing Education Courses, Lunch & Learns and YouTube videos
- Detailed case studies, award-winning project briefs, and SIP project USA map

Get all this and much, much more at www.sips.org

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Photo courtesy of SIPA

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Kelly's 1862 Timber Frame Home, Columbus OH

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Purtee Project, Moscow ID

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Trillium Studios, Norwell MA

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SIPA manufacturers convert architectural drawings into SIP shop drawings. Shop drawings specify SIP size, layout, assembly details and installation specifications. They are also used for factory fabrication purposes. Shop drawings are provided to the client, or their authorized representative, for review and approval. Commitment to the drawing review process is crucial. Attention to detail during review ensures fabricated panel accuracy, installation ease and meeting SIP performance expectations. Early interaction with the SIP manufacturer helps design optimization resulting in material cost savings and installation speed. SIPA manufacturers can share samples of SIP shop drawings for your review and understanding.

Photo courtesy of SIPA

SIPs are customized to varying levels depending on client needs

SIPA manufacturers offer differing levels of SIP fabrication. They include blank SIPs, prefabricated SIPs and ready-to-assemble (RTA) packages.

BLANK SIPs are the least expensive, but limit your installation speed advantage, create additional waste, and require a higher degree of installation skill as all cutting is performed onsite.

PREFABRICATED SIPs are designed and cut in the factory increasing site installation speed, improving fit and finish.

RTA packages include factory preinstalled internal lumber and headers maximizing onsite speed and efficiency.

Prefabricated is typical although, as labor becomes scarce, RTA packages are gaining in popularity. SIPA manufacturers can provide detail concerning benefits of each option.

Roof and wall assemblies

SIPs are compatible with conventional roof and wall claddings. Unlike traditional framing, there is no internal air cavity within the SIP. The foam core of SIPs is solid and continuous throughout the wall and roof, eliminating convection and condensation issues occurring in conventional cavities. It is important to ensure a code-approved weather-resistive barrier is specified under wall claddings and approved underlayments for roof covering. Designing for the appropriate climate zone will help maximize durability. In some climate zones, a back-ventilated assembly may be appropriate. Because SIPs use very little solid lumber, an increased fastener schedule could be required when attaching exterior cladding. Application of fully adhered products to SIPs roofs is not recommended. A separation layer should be added between the SIP roof and underlayment to avoid damage to the exterior SIP facing should there be a need to remove and replace the underlayment in the future.

Melody Lane, Wauseon OH

Factory cut electrical chases reduce electrician time in the field

Electrical chases are typically provided by SIPA manufacturers simplifying electrical rough-in and saving electrician labor by eliminating time spent drilling holes in studs. Vertical and horizontal chases are provided in SIP walls to assist with wiring. Standard practice is to cut chases horizontally at outlet and switch heights. Chases can be added to SIP roofs upon request. Use of surface mounted LED lighting is recommended in place of recessed lighting as they don't penetrate the envelope and jeopardize airtightness. Determining electrical requirements prior to SIP manufacturing reduces the inefficiency of field installation. Plan a shop drawing review with the electrician prior to final approvals to verify chase locations, accommodate electrical layout and ensure code compliance.

Design plumbing into interior walls

Eliminating the possibility of condensation or supply lines freezing within a SIP wall is an important design consideration. Plumbing should be relocated to interior walls wherever possible. If plumbing must be located on an exterior wall, it is recommended that an external chase be installed on the interior side of the SIP wall to conceal plumbing. Plumbing penetrations such as drain waste vent pipes can be placed perpendicularly through SIPs if thoroughly sealed to prevent air infiltration. Consult with a SIPA manufacturer if this is necessary.

To better understand the science of building with SIPs

Review "Builder's Guide to Structural Insulated Panels for all Climates" by Joseph Lstiburek. This resource provides invaluable assistance in Building Science related details and can be purchased online at Amazon or www.sips.org.

Heather's Home, Lake Weatherford TX

Building with SIPs:
CHECKLIST

The Structural Insulated Panel Association (SIPA) provides this checklist sharing the members' decades of knowledge to ensure the best experience and outcome for designers, builders, and owners of structural insulated panel (SIP) buildings. The Association's well-versed nuances of SIP design and construction will help you take advantage of SIP best practices and incorporate them into your projects.

CHECKLIST

High-Performance Building Envelope

SIPs are used to design high-performance building envelopes offering energy performance beyond conventional framing.

KEY POINTS:

☐ 1. SIP envelopes are intended to be high-performing. The objective is to build the building as tight as possible and allow mechanical ventilation to manage air flow. This will make for a healthier, more comfortable structure with improved indoor air quality (IAQ).

ACTION ITEMS:

☐ 1. Utilize SIP manufacturer approved sealing methods to limit air and vapor transmission through SIP joints.

☐ 2. Seal all penetrations (pipes, vents, chimneys) through the SIP envelope with manufacturer approved sealants.

☐ 3. Use a blower door test to verify your SIP installation.

☐ 4. Contact a SIPA manufacturing member at www.sips.org to learn about the benefits of SIP construction.

CHECKLIST

HVAC Systems

SIP envelopes deliver high-performance, extremely airtight envelopes. The energy efficiency and airtightness positively affect the HVAC design resulting in smaller unit requirements.

KEY POINTS:

- ☐ 1. Oversizing equipment jeopardizes building and equipment durability while needlessly increasing expenses.
- ☐ 2. SIP building designers, HERS raters, and HVAC professionals must accurately calculate thermal performance of SIP envelopes.
- ☐ 3. An energy model using ASHRAE Manual J or REM/Rate or Ekotrope design software should be used to verify proper equipment sizing.
- ☐ 4. High-performance structures designed and built extremely airtight must have mechanical make-up air. There are several options with varying degrees of complexity and cost ensuring a balanced HVAC system that will introduce fresh air.
- ☐ 5. Penetrations in the SIP envelope should be sealed to maximize airtightness.

ACTION ITEMS:

- ☐ 1. Work with an HVAC professional that is familiar with high-performing, extremely airtight structures.
- ☐ 2. Use energy calculations reflecting proper SIP foam core long-term thermal R-values along with energy efficiency and the extreme airtightness of the envelope to avoid HVAC equipment oversizing.
- ☐ 3. Keep all HVAC equipment and duct work inside the conditioned SIP envelope.
- ☐ 4. Consider specifying a heat recovery ventilator (HRV) or energy recovery ventilator (ERV), as referenced in ASHRAE 62.2 guidelines, for balanced fresh make-up air.

CHECKLIST

Structural Capabilities

SIPs have the structural strength to work well in virtually any design.

KEY POINTS:

- ☐ 1. The entire SIP works together to carry and manage loads. Therefore cross cutting SIP facings should only be done with manufacturer's or engineer's approval. Trimming of facings to attain a good fit is acceptable, as well as making cuts for small openings, such as electrical boxes.
- ☐ 2. Manufacturers publish construction manuals and load design charts that can be accessed to understand structural capacities.
- ☐ 3. SIPs are compatible with internal conventional framing when special structural requirements are met.
- ☐ 4. Point loads may dictate the need for additional structural components to be embedded internally. Avoid point loads over openings to allow SIPs to act as the header without the need for additional structural elements.

ACTION ITEMS:

- ☐ 1. Contact a SIPA manufacturing member at www.sips.org to request their structural information and evaluation report.
- ☐ 2. Follow manufacturer's recommended spline fastening schedules.
- ☐ 3. Check foundation or floor deck for square, level, and correct dimensions. Shim and adjust as needed.

CHECKLIST

SIP Sizes

SIPs can be manufactured in very large sizes (up to 8 x 24 feet). Large monolithic SIPs provide faster installation and reduce the number of connections which results in a much tighter envelope.

KEY POINTS:

- ☐ 1. SIPs are large and adequate room is needed for receiving, staging, and lifting panels. Three-inch-wide supports are recommended every 8 feet minimum to keep SIPs off the ground and to keep them level.
- ☐ 2. Lifting equipment such as a SkyTrak or telehandler (all terrain forklift) is recommended for unloading and stacking SIPs. Fork extensions for 8-foot-wide SIPs are recommended.
- ☐ 3. If the crew size or site conditions dictate smaller hand setting of SIPs is needed, be sure to make your manufacturer aware of limitations upfront.

ACTION ITEMS:

- ☐ 1. Contact a SIPA manufacturing member at www.sips.org to learn about their SIP size capabilities.
- ☐ 2. Use appropriate methods for moving, stacking, handling and erecting SIPs to maintain the integrity of the SIPs and promote the safety of the construction team.
- ☐ 3. Protect the SIPs from weather upon delivery until time of installation.

CHECKLIST

Shop Drawings

SIP manufacturers typically convert your architectural drawings into SIP shop drawings. Shop drawings specify SIP size, layout, assembly details and installation specifications. They are also used by the SIP manufacturer for accurate CNC fabrication.

KEY POINTS:

- ☐ 1. Understand the difference between purchasing SIPs without any fabrication, fabricated SIPs, and a full ready-to-assemble (RTA) package. Fabricated or ready-to-assemble SIP packages reduce waste onsite and require less time and skill.
- ☐ 2. Depending on complexity of design, need for engineering, permitting and possible revisions, the development of shop drawings is a process that relies on engagement from those reviewing these drawings on behalf of the building owner.
- ☐ 3. Window/door schedule will have to come with the plans so the designer can draw the proper plans.
- ☐ 4. SIPs are pre-cut in the factory per the shop drawings. Building the foundation as accurately as possible will help reduce onsite adjustment. Slightly larger in size is preferred to allow for minor adjustments onsite.
- ☐ 5. Shop drawings are provided for client review and approval.
- ☐ 6. There will be a lead time from shop drawing approval to delivery.

ACTION ITEMS:

- ☐ 1. Contact a SIPA manufacturing member at www.sips.org and ask for a sample SIP shop drawing for your review and understanding.
- ☐ 2. Involve the SIP manufacturer early to ensure SIP design optimization. Minor alterations can provide dramatic savings in material costs and speed of installation.
- ☐ 3. Communicate with manufacturer regarding any unique needs such as backers, structure in SIPs, solar panels, or hanging floor system to assure a quality build.
- ☐ 4. Understand what lumber and other accessories are coming with the SIP package and what must be ordered (top/bottom plates, bucks, posts, beams, etc.). This will reduce onsite delays.

CHECKLIST

SIP Fabrication

Different levels of SIP fabrication are offered by SIP manufacturers. They include blank SIPs, prefabricated SIPs, and ready-to-assemble (RTA) packages.

KEY POINTS:

- ☐ 1. Blank SIPs are the least expensive, but limit your speed of installation advantage, create additional onsite waste, and require a higher degree of installation skill as all cutting is performed onsite.
- ☐ 2. Prefabricated SIPs are designed and cut in the factory to increase speed of installation and improved fit and finish on the jobsite.
- ☐ 3. An RTA package includes internal lumber and headers provided and preinstalled in the factory to maximize speed and efficiency onsite.

ACTION ITEM:

- ☐ Contact a SIP manufacturing member at www.sips.org to learn about their SIP fabrication capabilities.

CHECKLIST

SIP Installation

SIPs are high-performance building envelopes and an experienced SIP installer is strongly recommended.

KEY POINTS:

- ☐ 1. Assure there is a capillary break between the SIPs and concrete floors, foundations and walls.
- ☐ 2. Typically, it is best to start installation of wall SIPs at a corner.
- ☐ 3. The use of ratchet straps to pull SIPs together can be very helpful during installation.
- ☐ 4. During installation, it is important to drill plates and connectors to allow access to electrical chases.
- ☐ 5. Brace SIPs appropriately during construction to withstand wind-related issues.
- ☐ 6. When installing roof SIPs, install splines and “chicken sticks” on the ground, to make the process easier.
- ☐ 7. Due to the “stack effect” (air exfiltration), the ridge joint is the most important joint in the house. Follow manufacturer’s ridge sealing detail to the letter!
- ☐ 8. A factory representative is recommended during the initial stages of installation for a first time SIP user, to help expedite the SIP installation, ensuring the system is installed as required and meets performance targets.
- ☐ 9. After the project has been erected, review all SIP joints to ensure properly nailed and sealed.
- ☐ 10. Training programs ensure that an educated installer understands the importance of properly installing and sealing the SIP package. Available programs include:
  - o SIPA online training course
  - o SIPA Registered Master Builder program
  - o SIPschool hands-on field training
  - o Carpenters International Training Fund for SIPs
  - o SIP manufacturer in-house training programs.

ACTION ITEMS:

- ☐ 1. Contact SIPA at www.sips.org to find experienced SIP installers.
- ☐ 2. Use a blower door test to verify your SIP installation and look for problems that can be fixed pre-drywall.
- ☐ 3. Ensure appropriate installation tools are available, such as lifting plates, sealant applicators, foam scoop, hot wire kit, 8’ level, sledgehammer, Fork Extensions, etc.
- ☐ 4. Spot check site dimensions versus SIPs is suggested, to assure a good fit, prior to lifting roof panels.
- ☐ 5. Use semi-permeable membranes on SIP roofs to allow for water vapor / moisture escape. Peel and stick membranes are generally not recommended to cover the entire roof. Use of non-permeable membranes on roof edges and valleys is acceptable.

CHECKLIST

Roof and Wall Assemblies

SIPs are compatible with conventional roof and wall claddings. As with all high-performance building envelopes, proper detailing is critical.

KEY POINTS:

- ☐ 1. Verify manufacturer recommended sealing of SIP joints is completed prior to installation of cladding.
- ☐ 2. In climate zones 4 and colder, SIP Tape should be installed on the interior of the structure. 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.
- ☐ 3. Application of fully adhered products to SIP roofs is not recommended. A separation layer is recommended to facilitate future roofing replacement.
- ☐ 4. SIPs can withstand minor wetting during the construction process. Covering SIPs with roof and wall cladding should be completed as soon as practical but only when SIPs are dry.

ACTION ITEMS:

- ☐ 1. Review “Builder’s Guide to Structural Insulated Panels for all Climates” by Joseph Lstiburek. This resource will provide invaluable assistance in Building Science related details and can be purchased online at Amazon or at www.sips.org.
- ☐ 2. Verify manufacturer recommended sealing of SIP joints is completed prior to installation of cladding.
- ☐ 3. Use code-approved underlayment and roof covering.
- ☐ 4. Use code-approved weather-resistive barrier under cladding for walls.
- ☐ 5. Follow cladding manufacturer’s recommendations for fastening to SIPs. If not available, review fastener capacities in OSB to determine fastening schedule.
- ☐ 6. Provide specific instructions to the wall cladding and roofing trades. This input should be consistent with the detailing needed for the climate and type of cladding.

CHECKLIST

Electrical

Electrical chases are typically provided by the SIP manufacturer to simplify the electrical rough-in, saving the electrician a great deal of time in the field.

KEY POINTS:

- ☐ 1. Vertical and horizontal chases are provided in SIP walls assisting with wiring at outlet and switch heights.
- ☐ 2. Wall and roof chases can be added or removed, prior to SIP manufacture.
- ☐ 3. Shop drawings will confirm all chase locations to avoid cutting SIPs in the field unnecessarily. Pre-planning for installation and special chase locations is critical.
- ☐ 4. Electrical chases should be sealed after electrical rough-in inspection to maximize airtightness.
- ☐ 5. An experienced SIP installer is your best insurance that the electrical rough-in will go smoothly.
- ☐ 6. Recessed lights are not recommended for installation in SIP roofs. Use of surface mounted LED lighting is recommended.

ACTION ITEMS:

- ☐ 1. Plan a review of the shop drawings with the electrician to verify chase locations to accommodate electrical layout and code compliance.
- ☐ 2. Do not cross cut SIP facings for electrical access.
- ☐ 3. Mark wiring holes on the deck or SIP so the electrician can easily find them.
- ☐ 4. Consult with your SIP manufacturer concerning electrical chases in roofs.

CHECKLIST

Plumbing

Plumbing should be placed within interior walls to protect the integrity of the high-performance envelope and to avoid the freezing of the supply lines in cold climates.

KEY POINTS:

- ☐ 1. Plumbing is recommended to be placed in interior walls to provide for an optimal exterior building envelope.
- ☐ 2. Minimize roof penetrations and consider consolidating all vents away from south facing roof planes for potential solar array.

ACTION ITEM:

- ☐ If plumbing needs to be placed in exterior walls, consult with SIP manufacturer.

Ford Residence, Hedgesville WV

Photo courtesy of SIPA

Discover how easily you can start or deepen your understanding of designing, installing, and excelling with SIPs in your next commercial or residential project with the decades of industry learnings, tips, and resources at your fingertips:

- SIP Industry AIA/MasterSpec Specification
- Designing with SIPs: Design Considerations
- Building with SIPs: Need to Know
- SIP Best Practice Deeper Dives
- Technical Bulletins
- Structural Insulated Panel (SIP) Engineering Design Guide
- Builder's Guide to SIPs book by Joseph Lstiburek of Building Science Corporation
- Building Education with SIPs Training (BEST) Videos and Certification
- AIA Continuing Education Courses, Lunch & Learns and YouTube videos
- Detailed case studies, award-winning project briefs, and SIP project USA map

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Structural Insulated Panel Association

SECTION 3:
SIP Design BP 1: High-Performance SIP Building Envelope

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SIPA
Structural Insulated Panel Association

SIP DESIGN-BP 1:

High-Performance SIP Building Envelope

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**
   - 1.1. **SIPs meet and exceed building code thermal envelope requirements and eliminate additional continuous insulation needs on the building exterior.**
   - 1.2. **SIPs provide extremely airtight structures, a key component improving indoor air quality (IAQ).**
   - 1.3. **SIPs are available in a range of thicknesses delivering exceptional thermal performance.**
   - 1.4. **Various SIP connections are available which minimize thermal bridging, lower installation costs, and install and seal with ease.**
   - 1.5. **Factory applied rigid foam insulation cores eliminate concerns over quality insulation installation (QII)**
   - 1.6. **Reduced HVAC requirements.**
2. HVAC Systems with SIPs
3. SIP Structural Capabilities
4. SIP Sizes
5. SIP Shop Drawings
6. SIP Fabrication
7. SIP Installation
8. SIP Roof and Wall Assemblies
9. SIP Electrical
10. SIP Plumbing

SIP DESIGN-BP 1:

High-Performance SIP Building Envelope

As a starting point, the American Institute of Architects considers a high-performance building one that integrates and optimizes all major high-performance building attributes, including energy efficiency, durability, life cycle performance and occupant productivity (which includes health). SIP building envelopes provide an important basis for enabling all these elements to be economically achieved.

SIP DESIGN-BP 1.1:
SIPs meet and exceed building code thermal envelope requirements and eliminate additional continuous insulation needs on the building exterior.

The 2018 International Energy Conservation Code (IECC) defines three paths to compliance: Prescriptive, U-factor, and the Building Performance path. Sections C402 and R402 describe the total building performance requirements. The Prescriptive path describes various assemblies and continuous insulation requirements. U-factor requirements are component based, i.e., a summation of the U-factor for each individual layer.

The SIPA-recommended path is to use the U-factor method to demonstrate SIP compliance with the building envelope requirements of the IECC. It is helpful to review a few key definitions from the 2018 IECC:

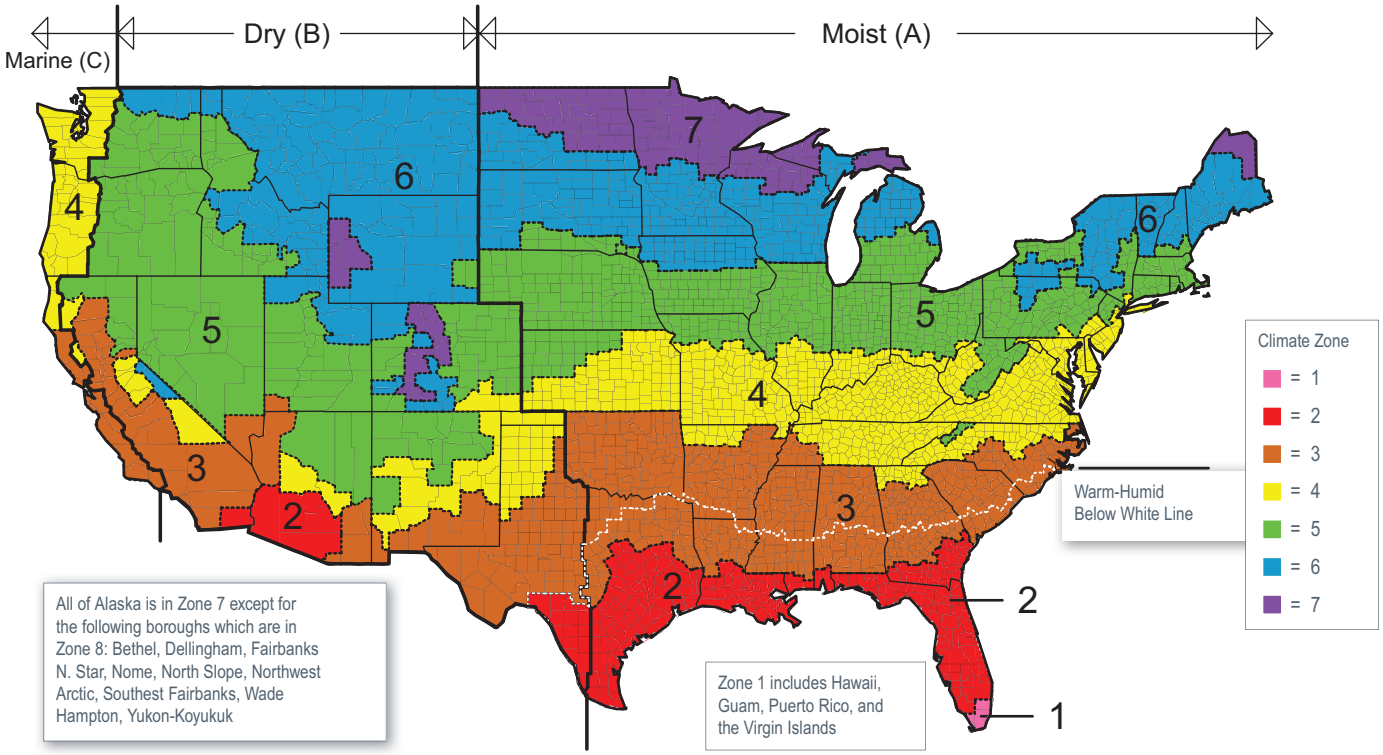
Continuous Insulation (ci): insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior, exterior, or is integral to any opaque surface of the building envelope.

R-value (thermal resistance): the inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady state conditions, per unit area ($h*ft^{2*0}F/Btu$).

U-factor (thermal transmittance): the coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films ($Btu/h*ft^{2*0}F$).

Sections C402 and R402 of the 2018 IECC require that the building envelope meet either the Prescriptive R-value requirements or the assembly U-factor requirements for the building envelope insulation assembly. The Prescriptive requirements for the envelope assembly in some climate zones may require the addition of exterior continuous insulation (ci). The Prescriptive path aims to eliminate thermal bridging energy losses from dimensional framing inside a wall which for opaque walls is typically high at 24 percent[1] framing factor for 2 x 4 framing at 16 inches on center or 22 percent[2] for 2 x 6 framing at 24 inches on center. Although the framing factor of SIPs is very low at only 3 percent[3], it still does not meet the IECC strict definition of continuous insulation because of the modest thermal bridging that occurs at various locations in the SIPs including plating around openings, wall top and bottom plates, corners and SIP roof connection details.

FIGURE 1.1:
U.S. DEPT. OF ENERGY CLIMATE MAPS BY COUNTY



[1] *ASHRAE Handbook of Fundamentals, 2010*

[2] Ibid.

[3] *2600 sq. ft. Home that has 50% Energy Savings in the Mixed-Humid Climate; ZEH5 2-Story, ORNL/TM-10081/08*

SIPs comply with the intention of continuous insulation for building envelope requirements in both the commercial and residential IECC by using the U-factor alternative path allowed by both sections C402 and R402. Section R402.1.5 of the 2018 IECC describes how to develop the UA method to demonstrate compliance using the U-factor method.

Versions of the IECC other than the 2018 have similar language regarding the UA alternative method of complying with the building envelope insulation requirements. Section references may be slightly different for code years other than 2018, but the concepts are similar. Tables 1.1 and 1.2 show the minimum thicknesses of SIPs for walls and roofs required to achieve the mandated U-factor by climate zone. Detailed scenario calculations supporting these tables can be found in the *Appendix* of this document.

TABLE 1.1

MINIMUM SIP THICKNESSES* TO MEET RESIDENTIAL 2018 IECC TABLE R402.1.5

	Roof/Ceiling		Wall	
Climate Zone**	**Roof/Ceiling U-factor**	**Minimum SIP thickness***	**Frame Wall U-factor**	**Minimum SIP thickness***
1	0.035	10-1/4-in.	0.084	4-1/2-in.
2	0.030	10-1/4-in.	0.084	4-1/2-in.
3	0.030	10-1/4-in.	0.060	6-1/2-in.
4 except Marine	0.026	12-1/4-in.	0.060	6-1/2-in.
5 and Marine 4	0.026	12-1/4-in.	0.060	6-1/2-in.
6	0.026	12-1/4-in.	0.045	6-1/2-in.
7 and 8	0.026	12-1/4-in.	0.045	6-1/2-in.

*Assumes standard Type I EPS foam cores; alternative foam type information available by consulting manufacturers. SIP thicknesses are nominal inches.
**See Figure 1.1

TABLE 1.2

MINIMUM SIP THICKNESSES* TO MEET COMMERCIAL 2018 IECC TABLE C402.1.4

Climate Zone**	1		2		3		4		5		6		7		8	
	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
Roofs																
Insulation entirely above roof deck	U=0.048	U=0.039	U=0.039	U=0.039	U=0.039	U=0.039	U=0.032	U=0.032	U=0.032	U=0.032	U=0.032	U=0.032	U=0.028	U=0.028	U=0.028	U=0.028
Minimum SIP thickness	6-1/2"	8-1/4"	8-1/4"	8-1/4"	8-1/4"	8-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"
Walls, above grade																
Wood framed and other	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.051	U=0.051	U=0.051	U=0.051	U=0.036	U=0.036
Minimum SIP thickness	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	6-1/2"	6-1/2"	6-1/2"	6-1/2"	8-1/4"	8-1/4"

*Assumes standard Type I EPS foam cores; alternative foam type information available by consulting manufacturers. SIP thicknesses are nominal inches.
**See Figure 1.1

SIP Design-BP 1.1.1:
2021 IECC update.

The 2021 International Energy Conservation Code (IECC) uses the U-Factor method as the residential compliance methodology for determining building thermal envelope compliance. Refer to R402.1.2 of the 2021 IECC. The R-value methodology is referred to as the alternative method. Refer to R402.1.3. The commercial provisions of the 2021 IECC use the U-Factor methodology as described in C402.1.4.

The U-Factor requirements for both residential (IECC table R402.1.2) and commercial (IECC table C402.1.4) have become more stringent in some climate zones. Climate Zone 0 has also been added to the climate zone map. Refer to Figure 1.1.1.

Tables 1.1.1 and 1.1.2 summarize the modified U-Factors for the various climate zones according to the 2021 IECC and the minimum SIP thickness required to meet or exceed the U-Factor requirements.

Reference Appendices 1.1 through 1.7 at the end of this document for additional assembly U-factor examples.

FIGURE 1.1.1:
IECC 2021 CLIMATE ZONE MAP

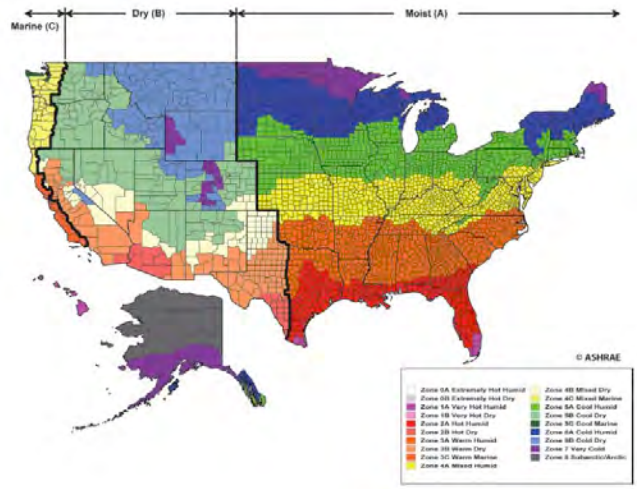


TABLE 1.1.1
MINIMUM SIP THICKNESSES* TO MEET RESIDENTIAL 2021 IECC TABLE R402.1.2

	Roof/Ceiling		Wall	
Climate Zone**	**Roof/Ceiling U-factor**	**Minimum SIP thickness***	**Frame Wall U-factor**	**Minimum SIP thickness***
0 and 1	0.035	10-1/4-in.	0.084	4-1/2-in.
2	0.026	10-1/4-in.	0.084	4-1/2-in.
3	0.026	10-1/4-in.	0.060	6-1/2-in.
4 except Marine	0.024	12-1/4-in.	0.045	6-1/2-in.
5 and Marine 4	0.024	12-1/4-in.	0.045	6-1/2-in.
6	0.024	12-1/4-in.	0.045	6-1/2-in.
7 and 8	0.024	12-1/4-in.	0.045	6-1/2-in.

*Assumes standard Type I EPS foam cores; alternative foam type information available by consulting manufacturers. SIP thicknesses are nominal inches.
**See Figure 1.1.1

TABLE 1.1.2

MINIMUM SIP THICKNESSES* TO MEET COMMERCIAL 2021 IECC TABLE C402.1.4

Climate Zone**	0 and 1		2		3		4 except marine		5 and marine 4		6		7		8	
	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
Roofs																
Insulation entirely above roof deck	U=0.048	U=0.039	U=0.039	U=0.039	U=0.039	U=0.039	U=0.032	U=0.032	U=0.032	U=0.032	U=0.032	U=0.032	U=0.028	U=0.028	U=0.028	U=0.028
Minimum SIP thickness	6-1/2"	8-1/4"	8-1/4"	8-1/4"	8-1/4"	8-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"
Walls, above grade																
Wood framed and other	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.051	U=0.051	U=0.051	U=0.051	U=0.051	U=0.051	U=0.032	U=0.032
Minimum SIP thickness	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	6-1/2"	6-1/2"	6-1/2"	6-1/2"	6-1/2"	6-1/2"	10-1/4"	10-1/4"

*Assumes standard Type I EPS foam cores; alternative foam type information available by consulting manufacturers. SIP thicknesses are nominal inches.
**See Figure 1.1.1

SIP Design-BP 1.1.2:
2024 IECC update.

The 2024 International Energy Conservation Code (IECC) is similar to the language from the 2021 IECC regarding building thermal envelope compliance requirements with a few additions and modifications.

The U-factor method C402.1.2 (Commercial) and R402.1.2 (Residential) is used for determining building thermal envelope compliance. The R-value alternative described in section R402.1.3 for residential applications and the Insulation component R-value method described in section C402.1.3 for commercial applications are also similar to the 2021 IECC requirements.

Component Performance methodology has been added to both the residential and commercial sections of the 2024 IECC.

Some of the U-factor values have been modified for the 2024 residential requirements, making the requirements less stringent.

Tables 1.1.3 and 1.1.4 summarize the modified U-Factors for the various climate zones (see Figure 1.1.1) according to the 2024 IECC and the minimum SIP thicknesses required to meet or exceed the U-factor requirements. Reference Appendices 1.1 through 1.7 at the end of this document for additional assembly U-factor examples.

TABLE 1.1.3

MINIMUM SIP THICKNESSES* TO MEET RESIDENTIAL 2024 IECC TABLE R402.1.2

	Roof/Ceiling		Wall	
Climate Zone**	**Roof/Ceiling U-factor**	**Minimum SIP thickness with OSB splines***	**Frame Wall U-factor**	**Minimum SIP thickness with OSB splines***
0 and 1	0.035	8-1/4-in.	0.084	4-1/2-in.
2	0.030	10-1/4-in.	0.084	4-1/2-in.
3	0.030	10-1/4-in.	0.060	6-1/2-in.
4 except Marine	0.026	10-1/4-in.	0.045	6-1/2-in.
5 and Marine 4	0.026	10-1/4-in.	0.045	6-1/2-in.
6	0.026	10-1/4-in.	0.045	6-1/2-in.
7 and 8	0.026	10-1/4-in.	0.045	6-1/2-in.

*Assumes standard Type I EPS foam cores; alternative foam type information available by consulting manufacturers. SIP thicknesses are nominal inches.
**See Figure 1.1.1

TABLE 1.1.4

MINIMUM SIP THICKNESSES* TO MEET COMMERCIAL 2024 IECC TABLE C402.1.2

Climate Zone**	0 and 1		2		3		4 except marine		5 and marine 4		6		7		8	
	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
Roofs																
Insulation entirely above roof deck	U=0.048	U=0.039	U=0.039	U=0.039	U=0.039	U=0.039	U=0.032	U=0.032	U=0.032	U=0.032	U=0.032	U=0.032	U=0.028	U=0.028	U=0.028	U=0.028
Minimum SIP thickness	6-1/2"	8-1/4"	8-1/4"	8-1/4"	8-1/4"	8-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"	10-1/4"
Walls, above grade																
Wood framed and other	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.064	U=0.051	U=0.051	U=0.051	U=0.051	U=0.051	U=0.051	U=0.032	U=0.032
Minimum SIP thickness	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	4-1/2"	6-1/2"	6-1/2"	6-1/2"	6-1/2"	6-1/2"	6-1/2"	10-1/4"	10-1/4"

*Assumes standard Type I EPS foam cores; alternative foam type information available by consulting manufacturers. SIP thicknesses are nominal inches.
**See Figure 1.1.1

SIP DESIGN-BP 1.2:
SIPs provide extremely airtight structures, a key component improving indoor air quality (IAQ).

A handy building science mantra *'build tight and ventilate right'* is often spoken as a requirement of energy-efficient, high-performance structures. Many think a building envelope can be 'too tight' not allowing in any fresh air. This is not true. The correct statement is that efficient, low-air-leakage buildings require make-up fresh-air supplies which come from intentional routes and not from arbitrary holes, gaps and leaks. Unfiltered air leaking into structures often unintentionally brings dust and other external contaminates which lower indoor air quality (IAQ).

Building air leakage is measured by performing a blower door test using specially designed fans to pressurize the structure. Home Energy Rating System (HERS) technicians are specially trained and credentialed by the Residential Energy Services Network (RESNET) to perform these tests which measure the amount of air leakage expressed in air changes per hour at the standard air pressure of 50 pascals (ACH50). The resulting leakage information is used to properly size HVAC equipment. Without realistic air leakage data, HVAC systems are usually oversized to accommodate high leakage rates (10.0 to 20.0 ACH50) typical in decades of leaky older structures. SIPs provide high-performance enclosures with very little air leakage, usually less than 2.0 ACH50. The HVAC systems historically installed in older homes will be oversized for SIP structures, so the proper ACCA Manual J sizing calculation must be computed using the actual air leakage values.

Air leakage information is so important that it is required for above-code performance programs like the U.S. Department of Energy's ENERGY STAR and Zero Energy Ready Home certifications, Passive House, U.S. Green Building Council's LEED, Green Building Initiative's Green Globes, or NAHB's National Green Building Standard.

Illustrating how mainstream low-air-leakage SIP installations are, several typical examples from SIPA's recent Building Excellence Awards with blower door test data show air leakage rates much less than 2.0 ACH50. Examples include the South Dakota affordable community 1,400 sq. ft. home with 1.0 ACH50; the Atwater Minnesota 3,500 sq. ft. home with 0.54 ACH50; the Baldwin City Kansas 866 sq. ft. small house with 1.59 ACH50; the Blaine Minnesota 8,200 sq. ft. commercial brewery with 1.39 ACH50; and North Dakota's 2,500 sq. ft. LEED Platinum residence with 0.42 ACH50. Read their detailed project case studies at www.sips.org/projects.

SIP research homes built by the Department of Energy's Oak Ridge National Laboratory (ORNL) have infiltration rates as low as 0.03 natural air changes per hour (ACHnat) or approximately 0.9 ACH at 50 pascals (Pa) of pressure differential (ACH50). Similarly sized stick framed homes in the same subdivision averaged blower door test results ranging from 6.0 to 7.5 ACH50. Current 2018 IECC codes require air leakage rates equal to or less than 5.0 ACH50 in the warmer, southern climate zones and equal to or less than 3.0 ACH50 in cooler climate zones. More current IECC codes are tightening the requirements in all zones to no more than 3.0 ACH50.

Commercial projects also benefit from using SIPs. The renowned energy-efficient Rocky Mountain Institute selected SIPs for its 2016 Innovation Center located high in the mountains of Basalt, Colorado. At almost 15,610 sq. ft., this building is net-zero, LEED Platinum and the largest Passive Certified structure in the world, with an air leakage rate of 0.36 ACH50 (97 percent less leakage than typical commercial buildings). With an energy use intensity of 15.9 kBtu/sq.ft./year, the building is designed to deliver two times more energy than it uses. The 10.8 percent premium to achieve net-zero is paid back in less than four years with the help of its high-performance SIPs. With virtually airtight envelopes, SIPs improve IAQ creating healthier homes and businesses.

Reducing unwanted air leakage requires sealing and precise alignment of framing, insulation and air-barriers – which is easier when building with large SIPs with fewer joints, and can be extremely difficult to achieve with traditional enclosures made of many pieces and layers.

ASHRAE standards 62.1 for commercial and 62.2 for low-rise residential building are referenced by building codes to properly calculate requirements for mechanical ventilation systems to provide minimum amounts of fresh air and exhaust strategies depending on occupant loads intended for various building types. Both fresh air dilution and stale indoor air extraction are needed to lower fumes from combustion appliances, adhesives, cleaning agents, radon, formaldehyde and other gases and particulates. Regular carbon dioxide and moisture from people breathing, cooking and showering must be managed continuously.

Mechanical ventilation or air exchange systems control purposeful introduction of fresh outdoor air into the conditioned space. Two methods of controlled mechanical ventilation are predominant.

Heat Recovery Ventilator (HRV)
An air to air heat exchanger unit that continually exchanges stale inside air for fresh outside air. As the two separate air streams pass through the unit, the heat from the exhaust air raises the temperature of the incoming air. This exchange creates a healthier indoor environment while providing energy recovery and savings. No moisture is exchanged between the air streams. HRVs are typically a predominantly cold, dry climate device.

Energy Recovery Ventilator (ERV)
An air to air heat exchanger unit that continually exchanges stale inside air for fresh outside air. As the two separate air streams pass through the unit, the heat and moisture from the exhaust air raises the temperature and humidity of the incoming air. This exchange creates a healthier indoor environment while providing energy recovery and savings. No moisture is exchanged between the air streams. ERVs are typically a predominantly warm, humid (or mixed-humid) climate device.

More information on air leakage, air exchange, and the HRV/ERV topic can be found in *SIP Design Best Practices 2: HVAC Systems with SIPs* and in the *Builder's Guide to Structural Insulated Panels (SIPs)* by Joseph Lstiburek, Chapter 11–HVAC (book available for purchase at www.sips.org or www.amazon.com).

SIP DESIGN-BP 1.3:
SIPs are available in a range of thicknesses delivering exceptional thermal performance.

SIPs are commonly manufactured in 4-1/2-inch, 6-1/2-inch, 8-1/4-inch, 10-1/4-inch and 12-1/4-inch nominal thicknesses with the 4-1/2-inch and 6-1/2-inch-thick SIPs typically used for walls and the thicker SIPs typically used for roofs. Thicker SIPs have higher R-values with correspondingly higher energy efficiency ratings.

Insulation is one of the key components of any energy-efficient home or commercial building. With heating and cooling accounting for 50 percent of energy use in the average home, the insulation type used can save thousands of dollars in utility bills over the building's life. SIPs use rigid foam core insulation, typically expandable polystyrene (EPS) or sometimes polyurethane (PU), while traditional lumber framed construction typically uses fiberglass batts or other similar insulating materials.

Insulation is typically rated by R-value, which measures a material's thermal resistance. An insulating material with a higher R-value forms a more effective thermal barrier between the outside temperature and the conditioned space inside the home. EPS foam insulation R-value is a function of density. ASTM C578 Standard for Rigid, Cellular Polystyrene Thermal Insulation is the standard the rigid insulation industry uses to classify densities and R-values of foam plastics. The ASTM C578 standard describes multiple types of rigid insulation. Type I rigid insulation is typically used for SIPs. Type I insulation has a density ranging from 0.9 lb/ft3 to 1.14 lb/ft3 with an R-value ranging from 3.6 to 3.9. Type I foam is referred to as having a typical 'nominal' density of 1.0 lb/ft3 with an R-value of 3.85 as documented by third party testing verification for the insulation manufactures.

In the U.S., the R-value of insulation is determined using a standard testing method conducted in a controlled environment where there is no air movement and a mean temperature of 75°F. Minimum R-values for SIPs using this test method as the basis are shown in Table 1.3. It is noted that R-values for SIPs may vary slightly from manufacturer to manufacturer but EPS foam performance is stable over time and does not degrade with age.

TABLE 1.3
SIP THERMAL PERFORMANCE WITH EPS CORES

SIP Total Thickness* (EPS Type I)	R-value @ 75°F	U-factor @ 75°F	R-value @ 40°F	U-factor @ 40°F	R-value @ 25°F	U-factor @ 25°F	R-value @ 0°F	U-factor @ 0°F	R-value @ -25°F	U-factor @ -25°F	R-value @ -50°F	U-factor @ -50°F
4-1/2-in.	13.9	0.072	15.3	0.065	15.3	0.065	17.1	0.058	18.2	0.055	18.9	0.053
6-1/2-in.	21.1	0.047	23.3	0.043	23.3	0.043	26.1	0.038	27.8	0.036	28.9	0.035
8-1/4-in.	27.4	0.036	30.3	0.033	30.3	0.033	34.0	0.029	36.2	0.028	37.6	0.027
10-1/4-in.	34.6	0.029	38.3	0.026	38.3	0.026	43.0	0.023	45.8	0.022	47.6	0.021
12-1/4-in.	41.8	0.024	46.3	0.022	46.3	0.022	52.0	0.019	55.4	0.018	57.6	0.017

Note: R-values are based on 7/16-in. OSB Facers on the Panels
*Assumes standard Type I EPS foam cores; alternative foam type information available by consulting manufacturers. SIP thicknesses are nominal inches.

R-value alone does not tell the whole story. While laboratory tests that determine R-values provide a theoretical measure for comparing the thermal performance of roof and wall assemblies, they do not reflect how entire installed, insulated assemblies perform in a building. When real-world factors such as air infiltration (air leakage), extremely low temperatures, cavity convective looping and thermal bridging are present, field-installed fiberglass insulation in assemblies performs at less than half the predicted R-value. Research from numerous Department of Energy's Oak Ridge National Laboratory studies and side by side building installations has validated that installed SIP projects closely match the theoretically predicted R-value performance of the building and outperform traditional fiberglass insulation's error-prone theoretical vs. actual performance.

Current Federal Trade Commission truth-in-advertising regulations require the performance of all insulation types to be tested and compared at a reference mean temperature of 75°F. However, for some insulations, the R-value improves when tested at lower temperatures (more closely reflecting real-world conditions for when insulation is needed in cold climates) as shown in Table 1.3 for EPS foams. Some other insulation types perform worse at colder temperatures. Values from other SIP foam cores are available upon request from SIPA or manufacturers.

The Department of Energy's Oak Ridge National Laboratory has studied and tested the performance of entire wall assemblies in large sections. The resulting whole-wall R-value data reveals that a 4-1/2-inch SIP wall with EPS core rated at R-14 performed equally with a 2 x 6 wall with R-19 fiberglass insulation. For comparison the whole-wall R-value of SIPs versus conventional 2x framing is shown in Table 1.4.

A comparison of the whole-wall R-values from Table 1.4 for the two most common thicknesses of walls shows that SIPs are at least 50 percent more efficient than the conventional stud walls for the same thickness.

By supplying SIPs with varying thicknesses and corresponding R-values, the SIP industry allows design professionals to easily specify SIPs that will meet any end use energy code demands.

TABLE 1.4

SIP VS. FIBERGLASS WALL ASSEMBLY WHOLE-WALL R-VALUES

Wall assembly nominal thickness (inches)		Whole-wall R-value
4-1/2-in	SIP with EPS	14.1
4-1/2-in	2 x 4 fiberglass wall at 16-in. o.c.	9.8
6-1/2-in	SIP with EPS	21.6
6-1/2-in	2 x 6 fiberglass wall at 24-in. o.c.	11.0*

* Note: ORNL data: 2 x 6 at 24 inches on center with fiberglass batts with rounded shoulders, 2 percent cavity voids, no compression around wiring, paper facer stapled to inside of stud.

SIP DESIGN-BP 1.4:
Various SIP connections are available which minimize thermal bridging, lower installation costs, and install and seal with ease.

SIP connections can be achieved with single or double 2x conventional lumber, LVL's, I-joists, surface splines and box/block splines. Box/block and surface splines are ideal as they minimize thermal bridging when connecting two SIPs.

Unlike conventional framing at the joints, SIP joints are sealed to eliminate the flow of moisture and air. Some SIPA manufacturers also install splines in their factories, effectively reducing the cost of site time. Splines can be pre-drilled to connect with the adjacent wire chase, again allowing the SIP to be sealed and nailed off immediately in the field, minimizing electrician costs.

SIPs are more efficient than conventional framing because they do not have dimensional lumber framing members every 16 to 24 inches. This effect is measured by the framing factor or percentage of the wall assembly where wood studs displace insulation. In a typical 2 x 4 stud wall at 16 inches on center, 24 percent[4] of the wall is solid wood leaving less available space for insulation. In advanced framing where the studs are at 24 inches on center the framing factor falls to approximately 22 percent[5] solid wood. In a typical SIP wall, the framing factor is much lower at only 3 percent[6]. The lower the framing factor, the less thermal bridging and the more insulation in the wall.

What is Thermal Bridging?
In Images 1.1 and 1.2 of an 8-1/4-inch SIP roof in Washington state, the SIP spline joints have I-joist splines for added structural strength. The I-joist spline acts as a thermal bridge or short circuit as would any other type of spline. Heat from inside the home flows outward and melts the roof frost at each panel joint connected by the I-joist splines. By contrast, the higher-insulating solid EPS foam cores of the SIPs to each side of the joint connections (with an approximate R-3.8/inch insulating value) resist the heat flow from the warm inside conditions and do not melt the frost.

IMAGE 1.1:
SIP ROOF WITH I-JOIST SPLINES

IMAGE 1.2:
SIP ROOF WITH I-JOIST SPLINES

[4] ASHRAE Handbook of Fundamentals, 2010

[5] Ibid.

[6] 2600 sq. ft. Home that has 50% Energy Savings in the Mixed-Humid Climate; ZEH5 2-Story, ORNL/TM-10081/08

While thermal bridging does occur in both SIP and traditionally framed construction, the larger distances between SIP splines connecting wider panels is typically less than closer spaced roof rafters or trusses. These photos help to train one's eyes to spot the difference in real-world conditions.

Images 1.3 and 1.4 are of home garages in Minneapolis, MN taken the same day. Image 1.3 has a 10-1/4-inch-thick SIP roof with I-joist splines connecting the SIPs. Like the SIP roof in Images 1.1 and 1.2, the reduced insulating value of the wooden I-joist acts as a thermal bridge transmitting the heat from inside the home to the roof surface and melting the frost. To each side of the I-joists, the solid foam cores insulate much better and don't melt the frost.

Using a better insulating box/block spline instead would eliminate the thermal bridging; see Spline Details 1.1 through 1.7 on pages 14 and 15.

Contrastingly, Image 1.4, with no insulation between the studs, illustrates the opposite effect. The frost is melting between the trusses due to poorer insulating performance in that space, allowing heat to escape from inside the garage. There is still frost above the wooden trusses which are insulating better than no insulation and just the roof decking material.

The message from nature here is that **more** roof frost means **better** insulation and fewer thermal bridges; **less** frost means **worse** insulation or more thermal bridging.

IMAGE 1.3:
SIP GARAGE ROOF

IMAGE 1.4:
TRADITIONAL GARAGE ROOF

Thermographic Image 1.5 below shows the lower R-value dimensional lumber as thermal bridges with a blue color in the wall transmitting much more energy at each stud compared to the higher R-value insulation to each side with a warmer green color depicting less energy transmission. By contrast, the SIP wall and roof surfaces in Image 1.6 illustrate a uniform temperature surface with minimal thermal bridging/energy leaks of dimensional lumber except at the top wall/roof juncture. Notice the contrasting thermographic red color depicting the heat generated from the center ceiling light. The uniform temperature of SIP walls improves the sense of comfort for occupants due to less radiant effects of the wall surface temperature differing significantly from the room air temperatures.

Images 1.7 and 1.8 are of the same SIP house in Minnesota on a 15°F winter morning. Notice no thermal bridging in the walls or roof and very uniform, consistent temperatures shown by the same colors along the wall and roof. The superior SIP energy performance of low framing factors providing minimal thermal bridging can be easily recognized in Image 1.7.

IMAGE 1.5:
DIMENSIONALLY FRAMED WALL WITH THERMAL BRIDGING AT STUDS (IN BLUE)

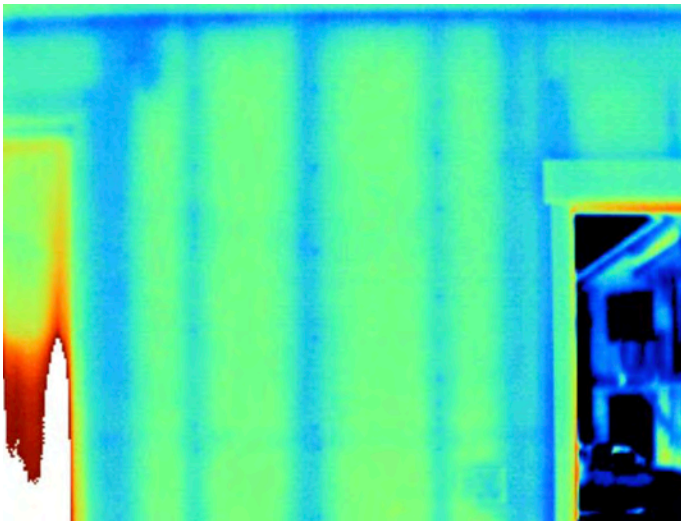


IMAGE 1.6:
SIP GARAGE WITH LOW THERMAL BRIDGING IN WALL/ROOF

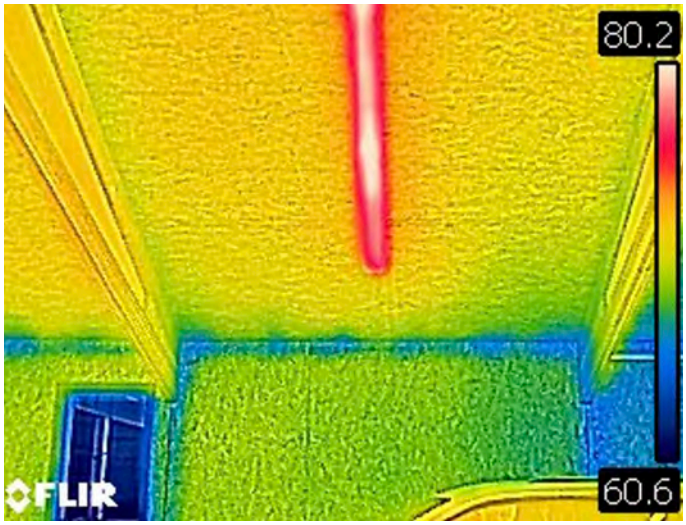


IMAGE 1.7:
MINNESOTA SIP HOUSE (THERMAL)

IMAGE 1.8:
MINNESOTA SIP HOUSE (PHOTO)

Since SIP roofs provide both the structure and the insulation all in one assembly, there is no need for attics, ceiling insulation, soffit vents, attic vent chutes, ridge vents or attic ventilation. Elimination of these saves construction time, complexity and money. Moreover, not having attic vents keeps insects, rodents and burning fire embers from entering the attic.

Images 1.9 and 1.10 contrast a neighboring stick frame wall and truss roof home the same winter morning. Notice the roof thermal bridging lines between the truss locations. The warmer, red color along the roof eaves illustrates heat loss from the top of the wall into the attic ventilation chutes. Warm air from the top of the wall enters into the attic through the eave soffit melting the frost.

In Image 1.10, notice that the melted frost lines across the roof surface uniformly align with the location of the air chutes.

In Images 1.11 and 1.12 of a Minnesota SIP wall and roof home with cathedral ceilings, the gable ends all show very consistent surface temperatures with no thermal bridges evident.

IMAGE 1.9:
MINNESOTA STICK HOUSE (THERMAL)

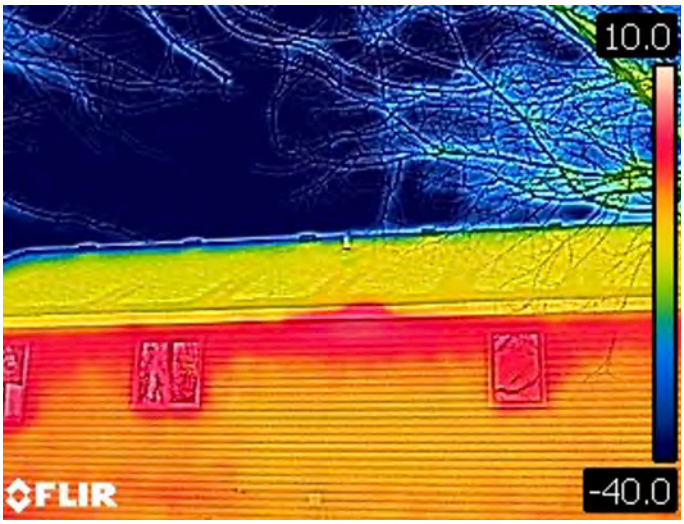


IMAGE 1.10:
MINNESOTA STICK HOUSE (PHOTO)

IMAGE 1.11:
SIP WALL (THERMAL)

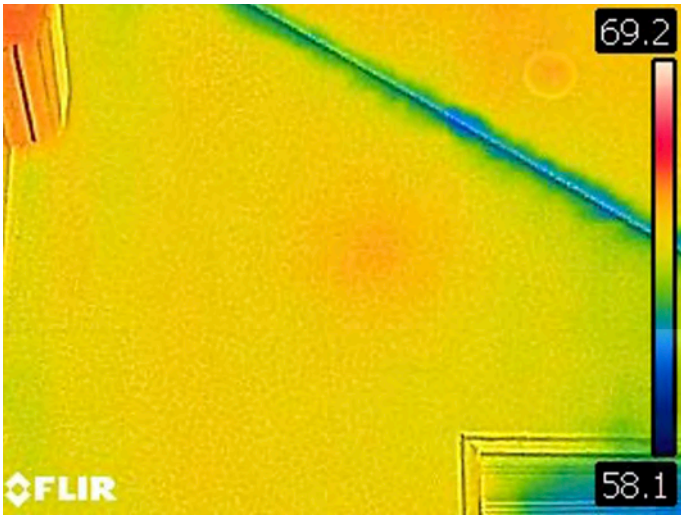
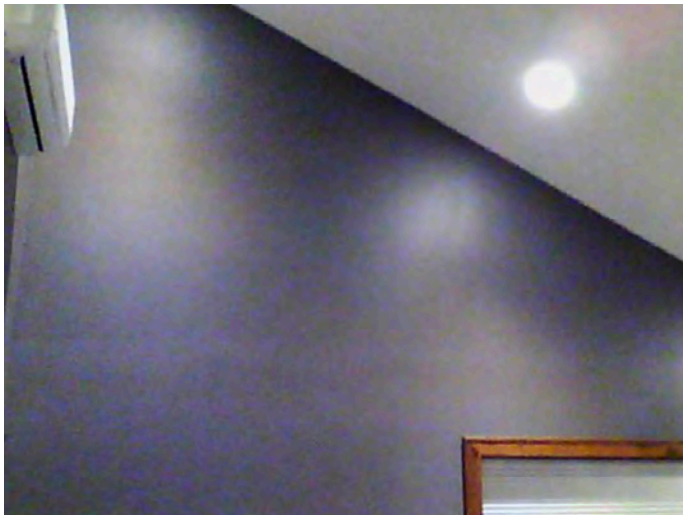


IMAGE 1.12:
SIP WALL (PHOTO)

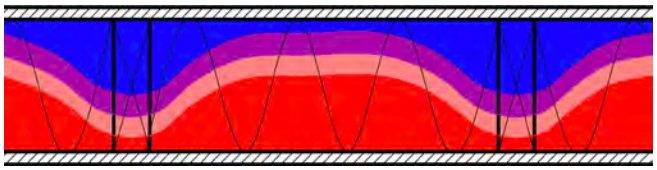


Figures 1.2 and 1.3 depict the temperature gradient in the SIP wall compared to the traditional stick framed wall. Notice how the temperature profile along the SIP wall surfaces is very constant while the fiberglass insulated cavity stud wall assembly varies widely.

These figures graphically illustrate the temperature gradient due to the thermal bridging and higher heat transfer at the studs, explaining the melting frost in earlier images.

FIGURE 1.2:
SIP WALL CROSS-SECTION WITH SURFACE SPLINE*

FIGURE 1.3:
TRADITIONAL STICK FRAMED WALL CROSS-SECTION WITH FIBERGLASS*



* red = hotter and blue = cooler temperatures

Joint Splines Systems

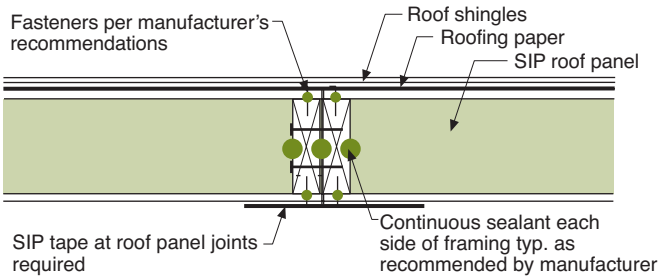
When designing with SIPs, a variety of panel joining spline technologies are available: surface splines, box/block splines, lumber splines, I-joists, etc. as illustrated in Details 1.1 – 1.7 which follow. Sealant applications around and inside these various joining spline technologies depend on geography, climate zone, seismic zone and manufacturer recommendations. Careful adherence to the specific referenced details is crucial to minimize air leakage and moisture infiltration with continuous sealant. Further discussion is available in *SIP Design Best Practices 7: SIP Installation.*

Many SIP installers report being able to install 2,000 sq. ft. of wall and roof panels per day with SIP ready-to-assemble (RTA) assemblies which include timesaving factory embedded components.

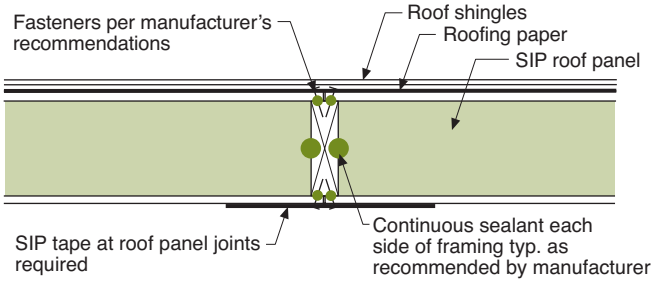
SIP connections are spelled out in shop drawings and provided to the client and builder to take away the guesswork from the installation process. This allows both the installer and the building official to review and approve the installation procedures.

Note that the following Details show typical recommendations. Consult manufacturer for job-specific requirements.

DETAIL 1.1:
SIP ROOF – DIMENSIONAL LUMBER DOUBLE SPLINE JOINT[7]



DETAIL 1.2:
SIP ROOF – DIMENSIONAL LUMBER SINGLE SPLINE JOINT[8]

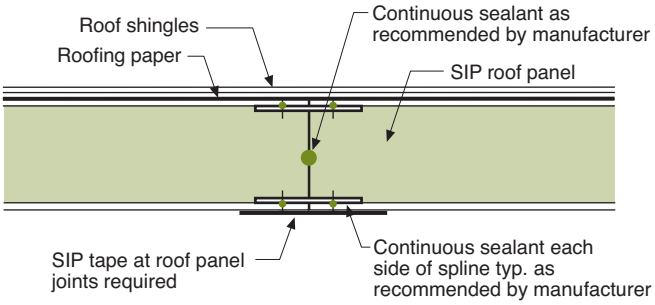


[7] Joseph Lstiburek, *Builder's Guide to Structural Insulated Panels (SIPs)*, (Building Science Corporation, 2008), Page 218, Figure 10.24b. Detail shows typical recommendations; consult manufacturer for job-specific requirements.

[8] Ibid., Page 218, Figure 10.24b. Detail shows typical recommendations; consult manufacturer for job-specific requirements.

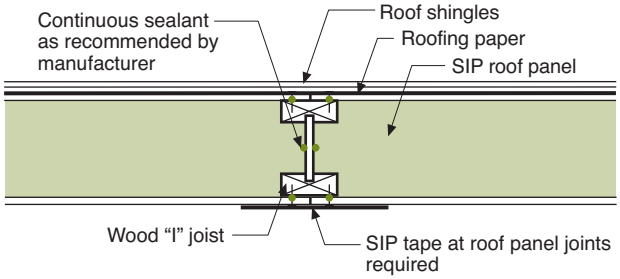
DETAIL 1.3:

SIP ROOF – SURFACE SPLINE JOINT[9]



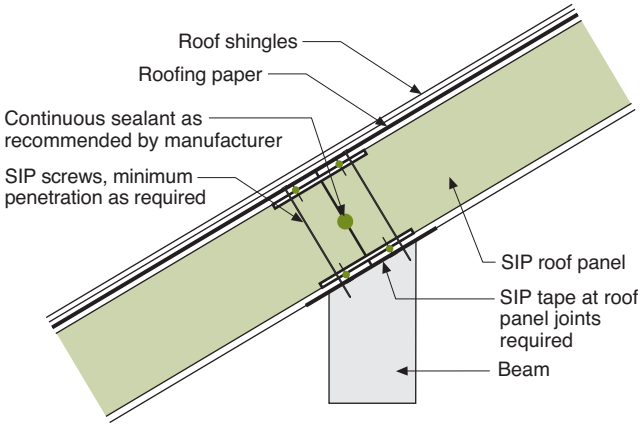
DETAIL 1.4:

SIP ROOF – I-JOIST SPLINE JOINT[10]



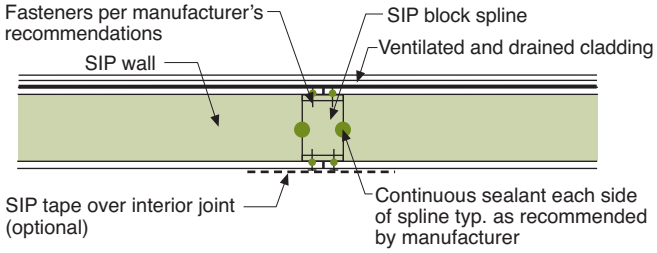
DETAIL 1.5:

SIP ROOF – BOX/BLOCK SPLINE JOINT[11]



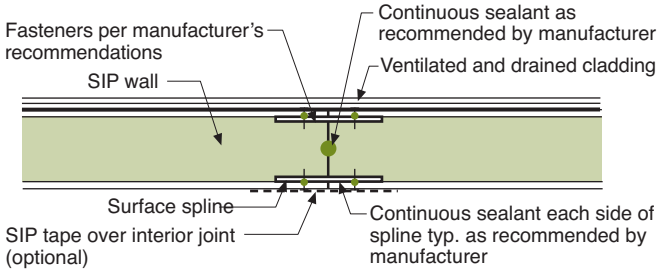
DETAIL 1.6:

SIP WALL – BOX/BLOCK SPLINE JOINT[12]



DETAIL 1.7:

SIP WALL – SURFACE SPLINE JOINT[13]



Details 1.1 through 1.7 depict different types of spline joints connecting panels (not to scale). As previously mentioned, solid lumber insulates less and transfers energy. Wood typically has an R-value of 1/inch compared to EPS foam at 3.6/inch minimum R-value as per ASTM C578 Type I foam. This is why the box/block and surface splines are more thermally efficient than solid wood. A box/block and surface spline can be thought of as an 'insulating spline.'

For more detailed information, be sure to reference *SIP Design Best Practices 8: SIP Roof and Wall Assemblies.*

[9] Ibid., Page 217, Figure 10.24a. Detail shows typical recommendations; consult manufacturer for job-specific requirements.

[10] Ibid., Page 217, Figure 10.24a. Detail shows typical recommendations; consult manufacturer for job-specific requirements.

[11] Ibid., Page 217, Figure 10.24a. Detail shows typical recommendations; consult manufacturer for job-specific requirements.

[12] Ibid., Page 209, Figure 10.14. Detail shows typical recommendations; consult manufacturer for job-specific requirements.

[13] Ibid., Page 208, Figure 10.11. Detail shows typical recommendations; consult manufacturer for job-specificrequirements.

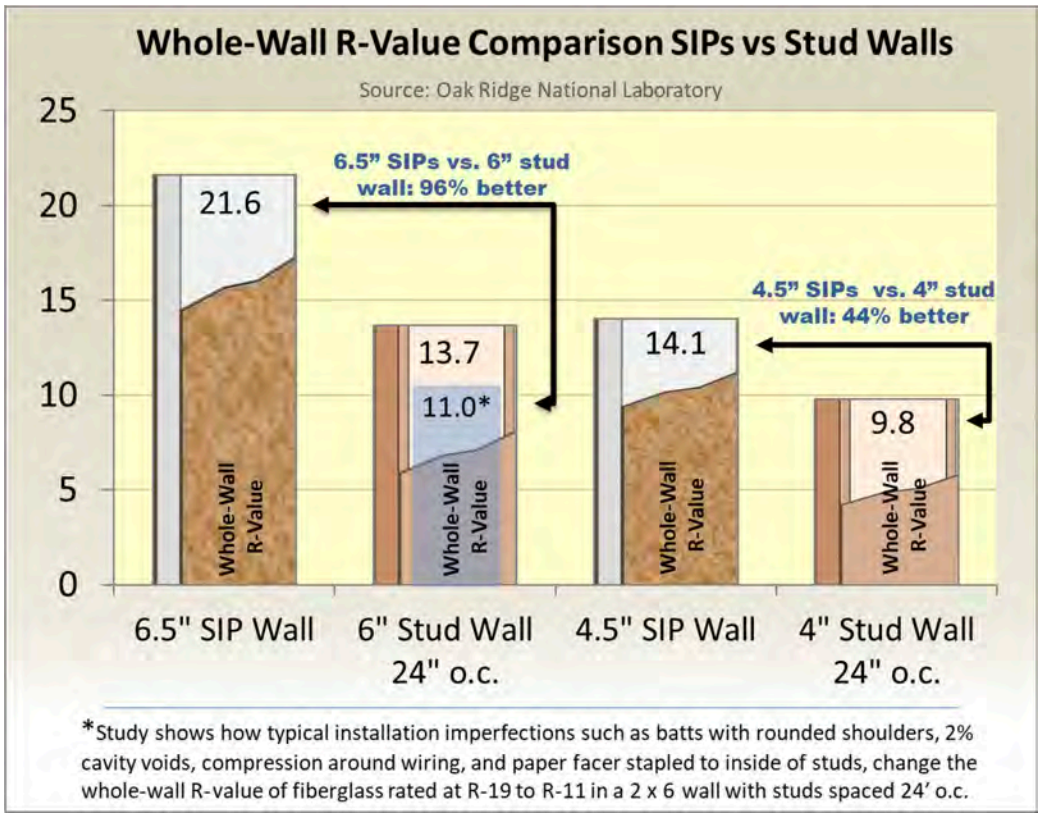
SIP DESIGN-BP 1.5:
Factory applied rigid foam insulation cores eliminate concerns over quality insulation installation (QII).

Many products insulate residential and commercial buildings. Most are factory produced and plant inspected under industry standards. Some are produced on the project site during application to the structure (e.g., spray foam) and are made from factory produced chemicals under industry standards. However, incorrect contractor field application of many insulation products into structural framing cavities jeopardizes attaining the predicted insulating performance due to often sloppy field installation and poor attention to detail or training. Short filling, voids, slumping and compressions/thickness variations are just some of the field installation errors regularly occurring. Field-installed insulation products may not perform to design expectations.

Because field insulation installation is so regularly plagued with errors, field inspection while the wall is open is required by code officials and energy raters. The resulting score is called a quality insulation installation (QII) score. If the installation is not perfect or average, it will be rejected. This score is also used as an input for energy modeling software to capture real-world reduced performance from the theoretical insulation values for modeling. Even the Department of Energy's Oak Ridge National Laboratory (ORNL) recognizes this frequent occurrence and requires a penalty factor to reduce the R-values recommended for stud framed walls.

Figure 1.4 illustrates the 'real-world' or 'whole-wall' R-values for these assemblies measured by the hot box testing at ORNL instead of calculated theoretical R-values. Notice how the lower framing factor of SIPs with less embedded lumber from studs in the wall (and thermal bridging) reveals better tested R-value performance compared to the traditional stud wall assemblies.

FIGURE 1.4:
INSULATION COMPARISON OF SIPS TO DIMENSIONALLY FRAMED WALLS AND INSTALLATION QUALITY EFFECTS



The damaging 'real-world' effects of average worker installation errors is illustrated by the dual values in the bar for the 2 x 6 stud wall at 24 inches on center assembly. Moving from a theoretically 'perfect' QII score for field labor installation of the fiberglass batt insulation to the more realistic 'typical' installation further reduces the measured real-world whole-wall R-value from R-13.7 to only R-11. This 2.7 R-value difference is a 20 percent reduction just from the effect of not having a perfect QII score. More importantly, notice even the real-world SIP whole-wall R-value of the thinner 4-1/2-inch SIP wall with R-14.1 outperforms both traditional construction cases: the 6-inch stud wall with only R-11 and the 4-inch wall with R-9.8.

SIPs are made with high-performance rigid foam cores which avoid many of the recurring shortfalls of field-applied fiber insulation products. The SIP's rigid foam core is factory manufactured under meticulous ASTM quality assurance standards and tested regularly and inspected by code recognized third-party auditing agencies. Next, the rigid foam core is factory laminated into an insulating and structural composite ensuring that the SIP's insulating performance is reliable for the life of the structure. The rigid foam SIP core has stable, high insulating power (expressed as R-value) resisting heat movement. Better than stud frame construction with cavities filled with porous fiber or particle insulations, the SIP rigid foam core is a solid material effectively eliminating air movement through walls and roofs. With air movement eliminated through and in the SIP, the following additional performance properties are achieved:

1. Reduction of air transfer from outside to inside and inside to outside of the structure; this is expressed as airtightness.
2. Elimination of convection looping in walls that occurs in open, non-solid insulation wall cavities. This also prevents smoke movement during fires.
3. Reduction of vapor movement in walls, whether by bulk air movement or diffusion.

SIP DESIGN-BP 1.6:
Reduced HVAC requirements.

SIP buildings are very well-insulated and airtight, which results in heating ventilation and air conditioning (HVAC) systems easily being oversized if old rules of thumb are used. When the HVAC system is too large, it tends to run for only short periods, or 'short cycles.' When an air conditioner short cycles, it will not run long enough to reach peak efficiency and does not effectively reduce humidity (latent load). An oversized air conditioner will create a wave of cool air which often causes the thermostat to get too quickly to setpoint before the entire structure cools off. Another disadvantage of an oversized air conditioner is the system tends to be noisier and require more maintenance. Similar problems can occur if the heating system is oversized. The system will short cycle causing uneven temperatures, more noise and early shut-off from the wave of warm air, making the building less comfortable. To eliminate these problems, ensure HVAC systems are designed by a qualified HVAC engineer according to ACCA Manual J. Avoid using outdated rules of thumb (e.g., estimating 1-ton a/c per 600 sq. ft. area) which do not consider (a) the well-insulating and airtight nature of SIPs as compared to traditional framing and (b) frequent substandard insulation installation methods.

The key to rightsizing HVAC equipment is minimizing load. While many people focus on R-value, an additional key element is airtightness. When lowering the air leakage rate, less outside air is effectively conditioned. SIPs outperform most systems due to their low leakage, stable R-values and low framing factor (about 5 percent) from the elimination of embedded dimensional lumber reducing thermal bridging.

Installed cavity insulations, whether friction fit fiber batts, sprayed foams or blown-in cellulose, all have potentially degraded performance from poor field installation quality. Due to frequently bad quality insulation installation (QII) easily lowering the performance, code inspectors verify it visually and provide a score to pass. This score is used in the modeling and rating software to properly predict loads. SIPs do not suffer from this installation risk since they are factory built with rigid foam insulation perfectly eliminating any cavities.

Once the envelope is installed, the overall quality is not known until a blower door leakage test can be performed, which is typically after drywall is hung and taped. SIP structures regularly achieve leakage rates below 2 air changes per hour at a pressure of 50 pascals (ACH50) to as low as 0.3 ACH50 which is below the Passive House standard of 0.6 ACH50. Of course, installation and quality of other key envelope system components like windows, plumbing and HVAC equipment must be addressed to achieve these low airtightness levels. These leakage results feed back to both the ACCA Manual J calculations and REM/Rate software for adjustment with the actual enclosure performance before it is roughed in to properly calculate loads and sizing of HVAC equipment.

Be aware: when modeling software asks for input on air leakage rates for various assembly types, ***always*** enter the tightest construction (least leaky) option for SIPs. This is especially important when actual tested air leakage values are not able to be entered into the software. Air leakage rates dramatically affect energy load calculations more than insulation values. Wrong data entered or software choice selections can easily oversize mechanical equipment and negatively affect building comfort, health and material durability.

Glossary of Terms

ACCA: Air Conditioning Contractors of America.

ACH50: the abbreviation for air changes per hour at 50 pascals (Pa) pressure differential and one of the most important metrics used to determine the energy efficiency of a house. It is the measurement of the rate of air leakage: the number of times the air volume in a building exchanges per hour at 50 Pa of pressure from a blower door test. It is considered equal to wind of approximately 25 miles per hour blowing on the outside of a building.

ACHnat: the natural air changes per hour in a building, as calculated by dividing ACH50 by the LBL Factor.

ASHRAE: the American Society of Heating, Refrigerating and Air-Conditioning Engineers (www.ashrae.org) is an American professional association seeking to advance heating, ventilation, air conditioning and refrigeration systems design and construction.

ASTM: American Society for Testing and Materials (www.astm.org), an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems and services.

Bottom Plate (SIP wall): the horizontal pieces of wood that are recessed between the OSB facers, in contact with the EPS foam core, at the bottom of a SIP wall.

CLT: cross-laminated timber, an engineered wood product.

Continuous Insulation (ci): insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior, exterior, or is integral to any opaque surface of the building envelope.

Dimensional lumber: wood lumber that is cut to pre-defined, standard sizes (e.g., 1-inch x 4-inch, 2-inch x 4-inch, etc.).

Engineered lumber: wood products which are manufactured by binding or fixing the strands, particles, fibers, or veneers, or boards of wood, together with adhesives or other methods of fixation, to form composite material. Examples include glulam, Parallam, CLT, I-joist, LVL and rim board.

EPS: expanded polystyrene foam insulation.

ERV: Energy Recovery Ventilator.

Framing factor: the ratio of the area of all wood structural members in contact with both the interior and exterior facers of the panels (e.g., studs and top and bottom plates) to the total surface area of the panel being considered.

HERS: Home Energy Rating System. The HERS index measures energy consumption from heating, cooling, water heating, lights and some appliances. The lower the index, the less energy a building is consuming. A HERS rating of zero signifies a net-zero energy building.

HRV: Heat Recovery Ventilator.

HVAC: heating, ventilation and air conditioning.

IAQ: indoor air quality.

IECC: International Energy Conservation Code.

I-joist: strong, lightweight, 'I' shaped engineered wood structural member used extensively in residential and light commercial construction projects.

LBL Factor: a factor based on climate region, number of stories of a building, and sheltering from wind which is used to convert to estimated air changes in a building by natural means, without a fan.

LEED: Leadership in Energy and Environmental Design; a sustainability rating system developed by the U.S. Green Building Council (USGBC).

LVL: laminated veneer lumber, an engineered wood product.

Manual J: the HVAC load calculation method recommended by the Air Conditioning Contractors of America (ACCA) to determine the amount of heating and cooling that a home requires to keep its occupants warm in the heating months and cool and dry in the cooling months.

ORNL: the U.S. Department of Energy's (DOE) Oak Ridge National Laboratory (ORNL) is the nation's largest multi-program science and technology laboratory.

OSB: Oriented strand board (OSB) is a type of engineered wood structural panel formed by adding adhesives and then compressing layers of wood strands..

QII: quality insulation installation.

R-value (thermal resistance): the inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady state conditions, per unit area ($h*ft^{2*0}F/Btu$).

REM/Rate: a residential energy analysis, code compliance and HERS software used to calculate heating, cooling, hot water, lighting and appliance energy loads, consumption and costs for single and multifamily homes.

SIPA: Structural Insulated Panel Association (www.sips.org), a non-profit trade association representing manufacturers, suppliers, dealer/distributors, design professionals and builders committed to providing quality structural insulated panels for all segments of the construction industry.

SIPs: Structural Insulated Panels, a high-performance building component for residential and light commercial construction.

Spline: connection system used to connect two panels together at vertical, in-plane joints. Many different spline systems are available including box/block, surface, I-joist, dimensional lumber and engineered lumber.

Thermal bridging: the movement of heat across an object that is more conductive than the materials around it. The conductive material creates a path of least resistance for heat. Thermal bridging can be a major source of energy loss in homes and buildings.

Top Plate: a horizontal member positioned between the SIP facers above the foam. Sits under the cap plate. For illustration, refer to Details 3.1 and 3.2 in *SIP Design Best Practices 3: SIP Structural Capabilities.*

UA alternative: a method for performing conductive energy trade-offs, trading off the R-values and U-factors of the thermal envelope, mathematically making the R-value and U-factor paths equal.

UA: the sum of U-factor times assembly area.

U-factor (thermal transmittance): the coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films ($Btu/h*ft^{2*0}F$).

Weighting %: the ratio of the area of a specific cross section of the panel with respect to the total panel surface area being considered.

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- Jeremy Dieken – Extreme Panel Technologies
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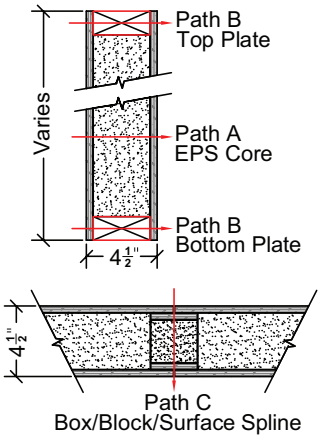
- Jack Armstrong, Executive Director
- Elaine Valby, Technical Coordinator

Appendix 1

Calculations for meeting minimal SIP thicknesses by climate zone as shown in Tables 1.1 and 1.2.

APPENDIX 1.1:

SIP 4-1/2-INCH WALL



Wood R/inch	1.25
Foam R/inch	3.85[1]
Core Thickness	3.625"
Spline Thickness	0.875"

Area based on 4' wide x 8' tall typical section	**(sq. in.)**
Total Area	4608
EPS Core	90.82%
Top & Bottom	3.13%
Box/Block/Surface Spline	6.05%

SIP Typical Nominal 4-1/2-inch Whole Wall

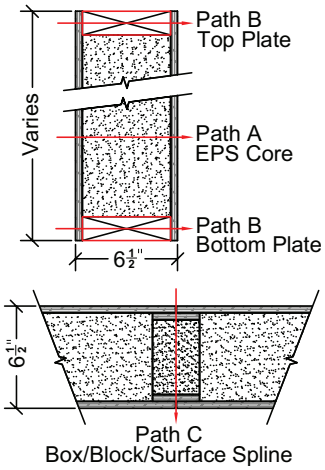
	Path A	Path B	Path C
R-value	EPS Core	Top & Bottom Plates	Box/Block/ Surface Spline
Inside Air Film	0.68	0.68	0.68
1/2-inch GWB	0.45	0.45	0.45
7/16-inch OSB	0.55	0.55	0.55
Framing	0.00	4.53	0.00
EPS Core	13.96	0.00	10.59
Spline	0.00	0.00	1.09
7/16-inch OSB	0.55	0.55	0.55
Exterior Finish - Vinyl	0.61	0.61	0.61
Outside Air Film (winter)	0.17	0.17	0.17
Path R-value	16.96	7.54	14.69
Path U-factor (1/Path R-value)	0.059	0.133	0.068
Weighting %	90.82	3.13	6.05
U x Weighting %	0.054	0.004	0.004
Overall U-factor[2]	**0.062**		
Effective R-value	**16.2**		

[1] Based on tested values of EPS suppliers

[2] Overall U-factor = U x Weighting % added for Paths A + B + C

APPENDIX 1.2:

SIP 6-1/2-INCH WALL



Wood R/inch	1.25
Foam R/inch	3.85[1]
Core Thickness	5.625"
Spline Thickness	0.875"

Area based on 4' wide x 8' tall typical section	**(sq. in.)**
Total Area	4608
EPS Core	90.82%
Top & Bottom	3.13%
Box/Block/Surface Spline	6.05%

SIP Typical Nominal 6-1/2-inch Whole Wall

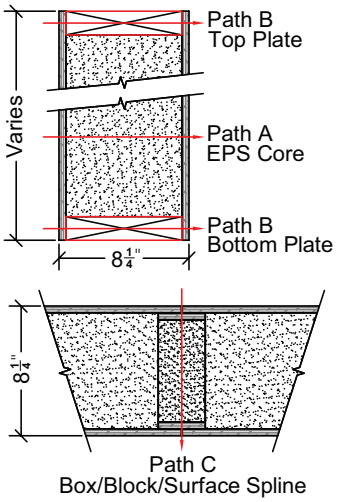
	Path A	Path B	Path C
R-value	EPS Core	Top & Bottom Plates	Box/Block/ Surface Spline
Inside Air Film	0.68	0.68	0.68
1/2-inch GWB	0.45	0.45	0.45
7/16-inch OSB	0.55	0.55	0.55
Framing	0.00	7.03	0.00
EPS Core	21.66	0.00	18.29
Spline	0.00	0.00	1.09
7/16-inch OSB	0.55	0.55	0.55
Exterior Finish - Vinyl	0.61	0.61	0.61
Outside Air Film (winter)	0.17	0.17	0.17
Path R-value	24.66	10.04	22.39
Path U-factor (1/Path R-value)	0.041	0.100	0.045
Weighting %	90.82	3.13	6.05
U x Weighting %	0.037	0.003	0.003
Overall U-factor[2]	**0.043**		
Effective R-value	**23.4**		

[1] Based on tested values of EPS suppliers

[2] Overall U-factor = U x Weighting % added for Paths A + B + C

APPENDIX 1.3:

SIP 8-1/4-INCH WALL



Wood R/inch	1.25
Foam R/inch	3.85[1]
Core Thickness	7.375"
Spline Thickness	0.875"

Area based on 4' wide x 8' tall typical section	**(sq. in.)**
Total Area	4608
EPS Core	90.82%
Top & Bottom	3.13%
Box/Block/Surface Spline	6.05%

SIP Typical Nominal 8-1/4-inch Whole Wall

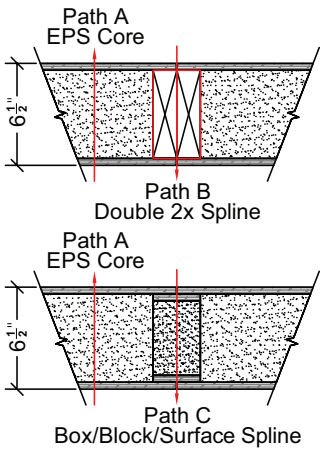
	Path A	Path B	Path C
R-value	EPS Core	Top & Bottom Plates	Box/Block/ Surface Spline
Inside Air Film	0.68	0.68	0.68
1/2-inch GWB	0.45	0.45	0.45
7/16-inch OSB	0.55	0.55	0.55
Framing	0.00	9.22	0.00
EPS Core	28.39	0.00	25.03
Spline	0.00	0.00	1.09
7/16-inch OSB	0.55	0.55	0.55
Exterior Finish - Vinyl	0.61	0.61	0.61
Outside Air Film (winter)	0.17	0.17	0.17
Path R-value	31.40	12.22	29.12
Path U-factor (1/Path R-value)	0.032	0.082	0.034
Weighting %	90.82	3.13	6.05
U x Weighting %	0.029	0.003	0.002
Overall U-factor[2]	**0.034**		
Effective R-value	**29.8**		

[1] Based on tested values of EPS suppliers

[2] Overall U-factor = U x Weighting % added for Paths A + B + C

APPENDIX 1.4:

SIP 6-1/2-INCH ROOF



Wood R/inch	1.25
Foam R/inch	3.85[1]
Core Thickness	5.625"
Spline Thickness	0.875"

Area based on 4' wide x 1' long panel with 2-2x Spline typical section	**(sq. in.)**
Total Area	576
EPS Core	93.75%
Double 2x Spline	6.25%
Box/Block/Surface Spline	0.0%

SIP Typical Nominal 6-1/2-inch Whole Roof

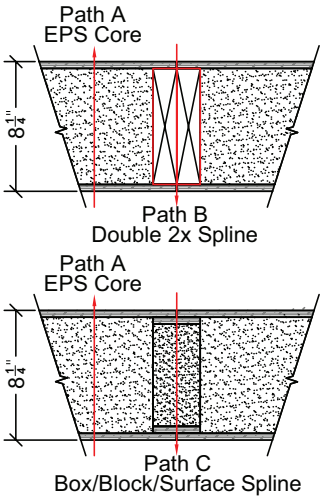
	Path A	Path B	Path C
R-value	EPS Core	Double 2x Spline	Box/Block/ Surface Spline
Inside Air Film	0.68	0.68	0.68
1/2-inch GWB	0.45	0.45	0.45
7/16-inch OSB	0.55	0.55	0.55
Framing	0.00	7.03	0.00
EPS Core	21.66	0.00	18.29
Spline	0.00	0.00	1.09
7/16-inch OSB	0.55	0.55	0.55
Asphalt Shingles	0.44	0.44	0.44
Outside Air Film (winter)	0.17	0.17	0.17
Path R-value	24.49	9.87	22.22
Path U-factor (1/Path R-value)	0.041	0.101	0.045
Weighting %	93.75	6.25	6.25
U x Weighting %	0.0383	0.0063	0.0028
	Path A + B *(least optimum)*		Path A + C *(most optimum)*
Overall U-factor[2]	**0.045**		**0.041**
Effective R-value	**22.4**		**24.3**

[1] Based on tested values of EPS suppliers

[2] Overall U-factor = U x Weighting % added for Paths A + B = 0.045 for the least optimum performance with double 2x spline; Path A + C improves by using most optimum performing box/block/surface splines to a better Overall U-factor = 0.041

APPENDIX 1.5:

SIP 8-1/4-INCH ROOF



Wood R/inch	1.25
Foam R/inch	3.85[1]
Core Thickness	7.375"
Spline Thickness	0.875"

Area based on 4' wide x 1' long panel with 2-2x Spline typical section	**(sq. in.)**
Total Area	576
EPS Core	93.75%
Double 2x Spline	6.25%
Box/Block/Surface Spline	0.0%

SIP Typical Nominal 8-1/4-inch Whole Wall

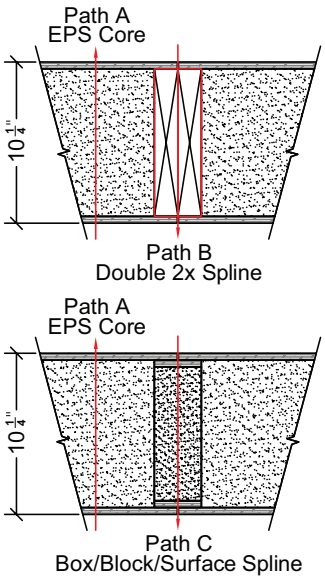
	Path A	Path B	Path C
R-value	EPS Core	Double 2x Spline	Box/Block/ Surface Spline
Inside Air Film	0.68	0.68	0.68
1/2-inch GWB	0.00	0.00	0.00
7/16-inch OSB	0.55	0.55	0.55
Framing	0.00	9.22	0.00
EPS Core	28.39	0.00	25.03
Spline	0.00	0.00	1.09
7/16-inch OSB	0.55	0.55	0.55
Asphalt Shingles	0.44	0.44	0.44
Outside Air Film (winter)	0.17	0.17	0.17
Path R-value	30.78	11.60	28.50
Path U-factor (1/Path R-value)	0.032	0.086	0.035
Weighting %	93.75	6.25	6.25
U x Weighting %	0.0305	0.0054	0.0022
	Path A + B *(least optimum)*		Path A + C *(most optimum)*
Overall U-factor[2]	**0.036**		**0.033**
Effective R-value	**27.9**		**30.6**

[1] Based on tested values of EPS suppliers

[2] Overall U-factor = U x Weighting % added for Paths A + B = 0.036 for the least optimum performance with double 2x spline; Path A + C improves by using most optimum performing box/block/surface splines to a better Overall U-factor = 0.033

APPENDIX 1.6:

SIP 10-1/4-INCH ROOF



Wood R/inch	1.25
Foam R/inch	3.85[1]
Core Thickness	9.375"
Spline Thickness	0.875"

Area based on 4' wide x 1' long panel with 2-2x Spline typical section	**(sq. in.)**
Total Area	576
EPS Core	93.75%
Double 2x Spline	6.25%
Box/Block/Surface Spline	0.0%

SIP Typical Nominal 10-1/4-inch Whole Roof

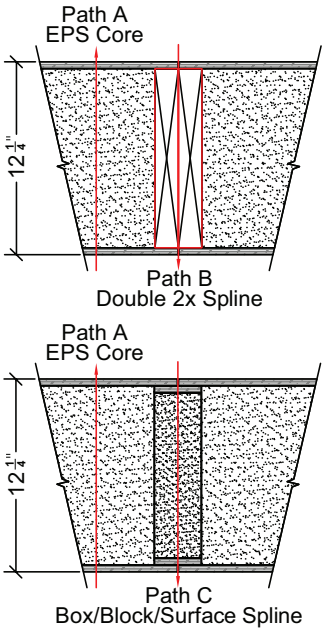
	Path A	Path B	Path C
R-value	EPS Core	Double 2x Spline	Box/Block/ Surface Spline
Inside Air Film	0.68	0.68	0.68
1/2-inch GWB	0.45	0.45	0.45
7/16-inch OSB	0.55	0.55	0.55
Framing	0.00	11.72	0.00
EPS Core	36.09	0.00	32.73
Spline	0.00	0.00	1.09
7/16-inch OSB	0.55	0.55	0.55
Asphalt Shingles	0.44	0.44	0.44
Outside Air Film (winter)	0.17	0.17	0.17
Path R-value	38.93	14.55	36.65
Path U-factor (1/Path R-value)	0.026	0.069	0.027
Weighting %	93.75	6.25	6.25
U x Weighting %	0.0241	0.0043	0.0017
	Path A + B *(least optimum)*		Path A + C *(most optimum)*
Overall U-factor[2]	**0.028**		**0.026**
Effective R-value	**35.2**		**38.8**

[1] Based on tested values of EPS suppliers

[2] Overall U-factor = U x Weighting % added for Paths A + B = 0.028 for the least optimum performance with double 2x spline; Path A + C improves by using most optimum performing box/block/surface splines to a better Overall U-factor = 0.026

APPENDIX 1.7:

SIP 12-1/4-INCH ROOF



Wood R/inch	1.25
Foam R/inch	3.85[1]
Core Thickness	11.375"
Spline Thickness	0.875"

Area based on 4' wide x 1' long panel with 2-2x Spline typical section	**(sq. in.)**
Total Area	576
EPS Core	93.75%
Double 2x Spline	6.25%
Box/Block/Surface Spline	0.0%

SIP Typical Nominal 12-1/4-inch Whole Wall

	Path A	Path B	Path C
R-value	EPS Core	Double 2x Spline	Box/Block/ Surface Spline
Inside Air Film	0.68	0.68	0.68
1/2-inch GWB	0.00	0.00	0.00
7/16-inch OSB	0.55	0.55	0.55
Framing	0.00	14.22	0.00
EPS Core	43.79	0.00	40.43
Spline	0.00	0.00	1.09
7/16-inch OSB	0.55	0.55	0.55
Asphalt Shingles	0.44	0.44	0.44
Outside Air Film (winter)	0.17	0.17	0.17
Path R-value	46.18	16.60	43.90
Path U-factor (1/Path R-value)	0.022	0.060	0.023
Weighting %	93.75	6.25	6.25
U x Weighting %	0.0203	0.0038	“0.0014

	Path A + B *(least optimum)*	Path A + C *(most optimum)*
Overall U-factor[2]	**0.024**	**0.022**
Effective R-value	**41.6**	**46.0**

[1] Based on tested values of EPS suppliers

[2] Overall U-factor = U x Weighting % added for Paths A + B = 0.024 for the least optimum performance with double 2x spline; Path A + C improves by using most optimum performing box/block/surface splines to a better Overall U-factor = 0.022

SECTION 4:
SIP Design BP 2: HVAC Systems with SIPs

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SIPA
Structural Insulated Panel Association

SIP DESIGN-BP 2:

HVAC Systems with SIPs

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

2.1. Oversizing equipment jeopardizes building and equipment durability while needlessly increasing expenses.

2.2. SIP building designers, HERS raters and HVAC professionals must accurately calculate thermal performance of SIP envelopes.

2.3. An energy model using ACCA Manual J or REM/Design software should be used to verify proper equipment sizing.

2.4. Airtightness: actual performance is best determined by a pre-drywall blower door test. A pre-construction estimate of less than 2.0 ACH is appropriate, and it is common to achieve less than 1.0 ACH50. Airtightness can be compromised if similar attention is not given to the other system components (e.g., windows, HVAC, plumbing, etc.).

2.5. Understand the R-value of the SIP provided. SIP R-value changes with thickness and R-values increase when temperatures drop. Code-required R-values are provided at 75˚F, but additional information is available at colder temperatures.

2.6. High-performance structures designed and built extremely airtight must have make-up air. There are several options with varying degrees of complexity and cost ensuring an HVAC system that will introduce fresh air.

2.7. Penetrations in the SIP envelope should be sealed to maximize airtightness.

3. SIP Structural Capabilities
4. SIP Sizes
5. SIP Shop Drawings
6. SIP Fabrication
7. SIP Installation
8. SIP Roof and Wall Assemblies
9. SIP Electrical
10. SIP Plumbing

SIP DESIGN-BP 2:

HVAC Systems with SIPs

SIP DESIGN-BP 2.1:
Oversizing equipment jeopardizes building and equipment durability while needlessly increasing expenses.

Bigger is not always better, neither are old rules of thumb. HVAC systems need to be designed for building performance. Leaky and poorly insulated buildings need larger heating, ventilation and air-conditioning systems (HVAC). High-performance buildings need significantly smaller HVAC systems. SIP buildings are very well-insulated and tighter, which results in HVAC systems easily being oversized if old rules of thumb are used to size equipment.

When the HVAC system is oversized, it tends to run for only short periods or 'short cycles.' When an air conditioner short cycles, it will not run long enough to reach peak efficiency and does not effectively reduce humidity (latent load) to a range of 40 percent – 60 percent relative humidity (RH) depending on outside temperature.[1] Lower than 40 percent RH dries mucous membranes and eyes making it easier for viruses to enter the body. Above 60 percent promotes mold growth which can irritate lungs. Another disadvantage of an oversized air conditioner is the system tends to be noisier and require more maintenance due to frequent starting and stopping.

Similar problems also occur if the heating system is oversized since equipment is often matched, and similarly oversized air conditioning coils can result, requiring larger ductwork to accommodate larger air flow. Again, the system short cycles causing uneven temperatures, more noise, and early shut-off from the wave of warm air making the building less comfortable. In the end, oversized equipment is not only more costly but can reduce operating performance, greatly shortening the equipment's lifespan.

[1] For additional information, see online resources such as www.hvac.com.

SIP DESIGN-BP 2.2:
SIP building designers, HERS raters and HVAC professionals must accurately calculate thermal performance of SIP envelopes.

Avoid using outdated rules of thumb (i.e., estimating 1-ton a/c per 600 sq. ft. area), which do not consider (1) the well-insulating and airtight nature of SIPs as compared to traditional framing, and (2) frequent substandard insulation installation methods.

The key to sizing HVAC equipment is matching capacity to load requirements. While many people focus on R-value, additional important elements are airtightness and properly installed insulation.

SIPs outperform most envelope systems due to their low air leakage, stable R-values, and low framing factor (about 3 percent) by eliminating embedded dimensional lumber, reducing thermal bridging. When lowering the air leakage rate, less outside air needs to be conditioned. Refer to ***SIP DESIGN-BP 2.4*** for typical SIP air leakage rates.

Installed cavity insulations, whether friction fit fiber batts, sprayed foams or blown-in cellulose, all have potentially degraded performance from poor field installation quality. Due to frequently bad quality insulation installation (QII) easily lowering the performance, code inspectors verify it visually and provide a score to pass. This score is used in the modeling and rating software to properly predict loads. SIPs do not suffer from this installation deficiency since they are factory built with rigid foam insulation eliminating cavities.

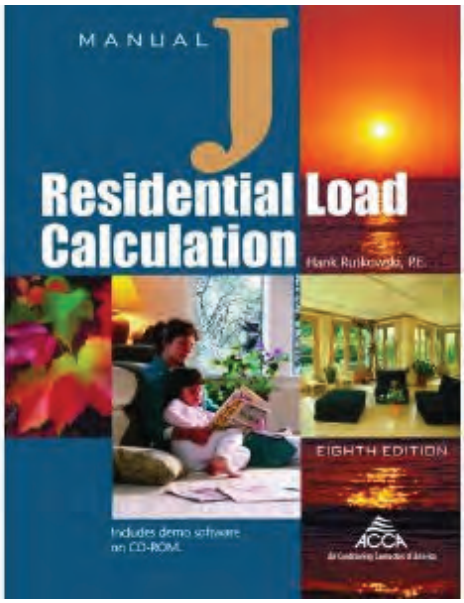
If a designer just calculates from simplified inputs, it distorts the end report. Entering a basic wall R-value, without identifying how the insulation is installed and the accurate amount of thermal bridging in the wall, will result in overvaluing a poor wall system and undervaluing a better system. When the envelope performance is not accurately calculated, it distorts the HVAC sizing causing the problems previously discussed. If designers and raters are not familiar with SIPs or how to model and design high-performance enclosures, they should research carefully how to input or seek help. These designs are critical to the workings of the entire project. See ***SIP DESIGN-BP 2.5*** in this chapter for more information.

SIP DESIGN-BP 2.3:
An energy model using ACCA Manual J or REM/Design software should be used to verify proper equipment sizing.

Consider an independent professional to perform an energy model using ACCA (Air Conditioning Contractors of America) Manual J and other software like REM/Design or Ekotrope to determine realistic loads for equipment sizing, because comfort, cost and proper HVAC performance are all interrelated. By using an independent professional, you are not relying on the same company which has a financial interest to sell you more equipment than you need.

Verify the system designer's record of accomplishment with installed systems and see if they are performing properly. Moreover, if a home is to be ENERGY STAR certified, the rater will have to enter the house design parameters into the REM/Rate system. This process should be done before the project is started, and the rater can give you the loads from the software to compare with the mechanical/HVAC supplier's recommendations. Do not be afraid to challenge or ask your mechanical/HVAC supplier questions and see proof that they completed the ACCA Manual S for equipment sizing and ACCA Manual D for proper duct design. The ACCA website (www.acca.org) can provide examples. Without completion of a detailed Manual S, there is no way to guarantee that the dehumidification (latent load) demands are properly taken into consideration. If the supplier cannot answer your detailed questions, they should not be installing or designing HVAC for your project. RESNET HERS Raters offer independent, third-party performance ratings to provide load designs.

Once the envelope is completed, the overall airtightness is confirmed by a blower door leakage test, which is typically done after drywall is hung and taped. Of course, installation and quality of other key envelope system components like windows, plumbing and HVAC equipment must be addressed to achieve these low airtightness levels. These leakage results feed back to both the ACCA Manual J calculations and REM/Rate software for adjustment with the actual verified enclosure performance to properly predict the modeled loads based on the installed HVAC equipment.



SIP DESIGN-BP 2.4:

Airtightness: actual performance is best determined by a pre-drywall blower door test. A pre-construction estimate of less than 2.0 ACH50 is appropriate, and it is common to achieve less than 1.0 ACH50. Airtightness can be compromised if similar attention is not given to the other system components (e.g,. windows, HVAC, plumbing, etc.).

HVAC professionals can account for airtightness in the design of the mechanical systems in SIP homes provided they have the proper information. Mechanical professionals use ACCA Manual J as the design guide to calculate the requirements for the heating and cooling systems in structures. Today, these calculations are computer based, but two important SIP properties need to be input into the software to provide meaningful results.

Manual J based calculations require the R-value of the insulation material and the air infiltration rate, or air leakage rate. The R-value is relatively straightforward. However, the air infiltration rate for SIPs must be addressed properly. Design guidelines for Manual J calculations suggest a reasonable air leakage assumption between 0.35 to 0.50 natural air changes per hour (ACHnat) unless a builder has data specific to their construction practices indicating they build tighter or looser. The Manual J recommendation is for stick built homes.

SIP manufacturers have blower door test data that has been generated from structures using SIPs for the exterior walls and roof of the building that test out at 0.04 to 0.06 ACHnat. These values for SIP structures are on the order of ten times better than what the Manual J design guidelines suggest.

SIPA recommends that a value of 0.05 ACHnat be used when performing Manual J heat loss calculations on structures using SIPs as the exterior walls and roof. If the software being used does not allow for numerical input, select the tightest option.

Be aware that blower door air leakage tests are also conducted by creating a pressure difference of 50 pascals between the inside and outside of the structure being tested. The leakage rate is often referred to as air changes per hour at 50 pascals of pressure or ACH50. Properly installed SIP structures regularly achieve leakage rates below 2.0 air changes per hour at a pressure of 50 pascals (ACH50), to as low as 0.3 ACH50 which is below the Passive House standard of 0.6 ACH50.

It is very important, since software systems often accept both of these testing system values (ACH50 and ACHnat), that the values are not confused or entered incorrectly since they differ by a factor of ten. It is easy to misplace or confuse the decimal place between the two by a factor of ten and have a resulting system design ten times too big.

Also be aware: when modeling software asks for input on air leakage rates for various assembly types, always enter the tightest construction (least leaky) option for SIPs. This is especially important when actual tested air leakage values are not able to be entered into the software. Air leakage rates dramatically affect energy load calculations, more than insulation values. Wrong data entered or software choice selections can easily oversize mechanical equipment and negatively affect building comfort, health and material durability.

SIP DESIGN-BP 2.5:
Understand the R-value of the SIP provided. SIP R-value changes with thickness and R-values increase when temperatures drop. Code-required R-values are provided at 75˚F, but additional information is available at colder temperatures.

Insulation is one of the key components of any energy-efficient home or commercial building. One of the common metrics used to evaluate the energy efficiency of various building systems, such as SIPs vs. conventional stick framing, is to compare R-values which measure a material's thermal resistance. An insulating material with a higher R-value forms a more effective thermal barrier between the outside temperature and the conditioned space inside the home.

In the U.S. the R-value of insulation is determined using a standard testing method conducted in a controlled environment where there is no air movement and at a temperature of 75°F. However, for colder climates the R-value should be evaluated at typical winter temperatures as shown in Table 2.1. It is noted that R-values may vary slightly from manufacturer to manufacturer.

TABLE 2.1

SIP R-VALUES AND U-FACTORS IMPROVE WITH FALLING WALL TEMPERATURES (MINIMUM INDUSTRY VALUES)

SIP Total Nominal Thickness (EPS Type I)	R-value @ 75^{0}F	U-factor @ 75^{0}F	R-value @ 40^{0}F	U-factor @ 40^{0}F	R-value @ 25^{0}F	U-factor @ 25^{0}F	R-value @ 0^{0}F	U-factor @ 0^{0}F
4 1/2"	13.9	0.072	15.3	0.065	16.0	0.062	17.1	0.058
6 1/2"	21.1	0.047	23.3	0.043	24.4	0.041	26.1	0.038
8 1/4"	27.4	0.036	30.3	0.033	31.8	0.031	34.0	0.029
10 1/4"	34.6	0.029	38.3	0.026	40.2	0.025	43.0	0.023
12 1/4"	41.8	0.024	46.3	0.022	48.6	0.021	52.0	0.019

NOTES:

1. EPS foam core minimum R-values used based on the ASTM C-578 standard at the lowest density (0.90 lb/ft3) in the Type I foam range. Higher density EPS and other foam types with associated higher R-values are typical for SIP applications. Consult specific SIP manufacturers for actual higher values and options. These values are provided as industry minimums for conservative, preliminary modeling purposes.
2. Listed SIP R-values are based on average wall temperatures (inside wall temperature + outside temperature divided by 2). In most U.S.-based designs, R-values above 00 F will be most common.
3. OSB R-values of 1.085 based on two 7/16" facers.
4. SIP thicknesses are nominal inches.

However, it is important to note that a comparison of R-values doesn't tell the whole story. While laboratory tests that determine R-values provide a relative measure for comparing the thermal performance of roof and wall assemblies, there are many factors that affect the building's performance. When real-world factors such as air infiltration, extreme temperatures and thermal bridging are present, field-installed fiberglass insulation can lose more than half its R-value. Research has repeatedly shown that SIPs with EPS core insulation provide a stable R-value over the life of the building.

The Department of Energy's Oak Ridge National Laboratory (ORNL) has studied and tested the performance of entire wall assemblies in large sections. The resulting whole-wall R-value data reveals that a 4-1/2-inch SIP wall rated at R-14 performed equally with a 2-inch x 6-inch wall with R-19 fiberglass insulation. For comparison, the whole-wall R-value of SIPs versus conventional 2x stick framing is shown in Table 2.2.

TABLE 2.2

Wall assembly thickness	Whole-wall R-value
4-1/2" SIP	14.1
2" x 4" wall at 16" on center	9.8
6-1/2" SIP	21.6
2" x 6" wall at 24" on center	13.7/11.0*

*The ORNL study shows how typical installation imperfections such as batts with rounded shoulders, 2% cavity voids, compression around wiring, and paper facer stapled to inside of studs, change the whole-wall R-value of fiberglass rated at R-19 to R-11 in a 2" x 6" wall with studs spaced 24" o.c.

A comparison of the whole-wall R-values from Table 2.2 for the two most common thicknesses of walls shows that SIPs perform 140 percent to 200 percent better than the conventional stick framed walls. This is due to low thermal bridging and low air leakage.

By supplying panels with varying thicknesses and corresponding R-values, the SIP industry allows design professionals to easily specify SIPs that will meet any end use energy code demands.

SIP DESIGN-BP 2.6:
High-performance structures designed and built extremely airtight must have make-up air. There are several options with varying degrees of complexity and cost ensuring an HVAC system that will introduce fresh air.

The list below represents some of the typical building systems intended to provide make-up air defined by ASHRAE as "any combination of outdoor and transfer air intended to replace exhaust air and exfiltration." Outdoor air is defined by ASHRAE as "ambient air that enters a building through a ventilation system, through intentional openings for natural ventilation or by infiltration."

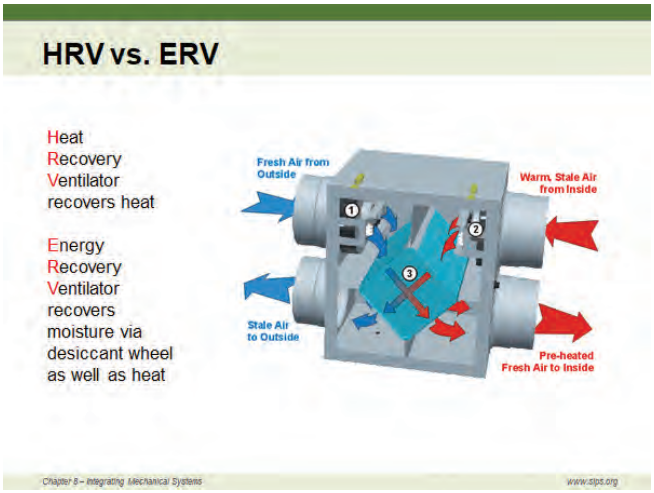
The list is in order of priority with the first (air to air exchangers) being the recommended approach for SIPs. Whatever ventilation strategy is chosen, a design professional with experience in the proper design of tight building envelopes should be involved in the HVAC design. Experts at Building Science Corporation recommend homes with air leakage rates less than 3.0 ACH50 should have mechanically driven make-up air for satisfactory indoor air quality. This is especially important for single story homes with typically little stack effect and homes with high occupancy built over a slab on grade. Since SIP homes are typically tighter than 3.0 ACH50, mechanical ventilation of some kind is always recommended.

1. **Air to air heat exchangers:** these small units generally draw air from source areas like kitchens and bathrooms where excess humidity is created. Moisture-laden warm air is carried through ducts to the unit where it transfers the heat through a core, similar in function to the radiator of a car, while carrying the moisture out of the structure. Thus, the exhaust air tempers or pre-heats the cold unconditioned but fresh air that is coming in from outside. These units are also known as Heat Recovery Ventilators (HRV) or Energy Recovery Ventilators (ERV).

2. **Exhaust-only systems:** these units come in many shapes and sizes, from simple one-room units to multiple-duct whole-house exhausts. This type of unit typically exhausts the stale air and relies upon natural infiltration to replace the exhausted air. Exhaust-only systems can create a negative pressure in the structure. As a health and safety precaution, it is always important to install only sealed combustion appliances in high-performance homes. If not, back drafting can lead to carbon monoxide poisoning and death for occupants.

3. **Ventilating windows:** these windows use a small grille to both exhaust and replace air in a house. They are manually operated and can be used in selected windows or in every window in a home.

4. **Air cleaners:** these units run the gamut from inexpensive tabletop versions to very sophisticated whole-house systems. They are used to remove particulate pollutants but generally are not designed for the removal of gaseous pollutants. Typically, these are not recommended for either humidity or radon control.



SIP DESIGN-BP 2.7:
Penetrations in the SIP envelope should be sealed to maximize airtightness.

Building science has taught us that a tight building envelope significantly contributes to the energy efficiency of the structure. Building science has also shown us that SIPs can significantly reduce air leakage through the building envelope. This reduction in air leakage contributes greatly to the energy efficiency of a SIP structure. Please reference ***SIP DESIGN-BP 2.4*** for additional information.

If a structure using SIPs is going to realize the reduced air leakage that contributes to the energy efficiency of the SIP system, the details relating to the sealing of the SIP joints, connections and penetrations through the SIP envelope need to be followed. Designers and contractors are encouraged to become thoroughly familiar with the SIP manufacturers' technical bulletins and details that describe proper use of sealants, SIP tape and expanding foam sealants used to minimize the effects of joints in the panels and penetrations through the envelope.

Expanding foam sealants compatible with EPS must be used to seal penetrations made in the SIP envelope during the construction process. This would include any penetrations from the construction process as well as penetrations for openings, HVAC, plumbing and electrical systems. These penetrations need to be thoroughly and completely sealed. Proper sealing of the electrical chases in panels as well as the electrical boxes within the panels would be included in this process.

By paying attention to the sealing of openings, penetrations, SIP joints and connections in a SIP structure, you will ensure that the structure has minimal air leakage through the exterior envelope, thus helping to maximize the energy efficiency of the SIP system.

Glossary of Terms

ACCA: Air Conditioning Contractors of America.

ACH50: the abbreviation for air changes per hour at 50 pascals (Pa) pressure differential and one of the most important metrics used to determine the energy efficiency of a house. It is the measurement of the rate of air leakage; the number of times the air volume in a building exchanges per hour at 50 Pa of pressure from a blower door test. It is considered equal to wind of approximately 25 miles per hour blowing on the outside of a building.

ACHnat: the natural air changes per hour in a building, as calculated by dividing ACH50 by the LBL Factor.

ASHRAE: the American Society of Heating, Refrigerating and Air-Conditioning Engineers (www.ashrae.org) is an American professional association seeking to advance heating, ventilation, air conditioning and refrigeration systems design and construction.

EPS: expanded polystyrene foam insulation.

ERV: Energy Recovery Ventilator.

HERS: Home Energy Rating System. The HERS index measures energy consumption from heating, cooling, water heating, lights and some appliances. The lower the index, the less energy a building is consuming. A HERS rating of zero signifies a net-zero energy building.

HRV: Heat Recovery Ventilator.

HVAC: heating, ventilation and air conditioning.

LBL Factor: a factor based on climate region, number of stories of a building, and sheltering from wind which is used to convert to estimated air changes in a building by natural means, without a fan.

Manual D: ACCA Manual D duct design distributes the correct amount of heating and cooling to each room based on the Manual J load calculation results. The furnace and A/C selected during the ACCA (Air Conditioning Contractors of America) Manual S process will determine the duct CFM for your exact humidity and winter and summer design temperatures.

Manual J: the HVAC load calculation method recommended by the Air Conditioning Contractors of America (ACCA) to determine the amount of heating and cooling that a home requires to keep its occupants warm in the heating months and cool and dry in the cooling months.

Manual S: ACCA Manual S provides specific procedures for selecting HVAC equipment against a set of Manual J loads and design conditions. Manual S uses OEM data and specifies how large or small the selected HVAC equipment capacity can be for exact humidity and winter and summer design temperatures when compared to the Manual J load calculation.

Natural air changes: the natural air changes per hour in a building, as calculated by dividing ACH50 by the LBL Factor.

QII: quality insulation installation.

R-value (thermal resistance): the inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady state conditions, per unit area ($h*ft^{2*0}F/Btu$).

REM/Rate: a residential energy analysis, code compliance and HERS software used to calculate heating, cooling, hot water, lighting, and appliance energy loads, consumption and costs for single and multifamily homes.

Short cycling: a condition in which an air conditioner goes through its on-and-off cycles too frequently, resulting in an uncomfortable environment, energy drain, and undue stress on the equipment itself.

SIPA: Structural Insulated Panel Association (www.sips.org), a non-profit trade association representing manufacturers, suppliers, dealer/distributors, design professionals, and builders committed to providing quality structural insulated panels for all segments of the construction industry.

SIPs: Structural Insulated Panels, a high-performance building component for residential and light commercial construction.

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SECTION 5:
SIP Design BP 3: SIP Structural Capabilities

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Structural Insulated Panel Association

SIP DESIGN-BP 3:

SIP Structural Capabilities

Introduction and How to Use This Document

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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**
   - **3.1. Manufacturers publish construction manuals and load design charts that can be accessed to understand structural capacities.**
   - **3.2. SIPs have been included in the IRC since the 2007 supplement to the 2006 IRC.**
   - **3.3. Structural capacities are recognized for compliance with Model Building Codes in evaluation reports from ICC-ES, ICC NTA, Intertek or IAPMO.**
   - **3.4. The structural capacity of SIPs changes with height/length, thickness and connection method.**
   - **3.5. SIP roofs offer great design flexibility to span long distances. SIPs can be combined with structural splines to span up to 24 feet. Exterior walls, beams, purlins, interior partitions, timber frame, or trusses constructed of either wood or steel are required to support a SIP roof.**
   - **3.6. SIPs are compatible with internal conventional framing.**
   - **3.7. Point loads may dictate the need for additional structural components to be embedded internally. Avoid point loads over openings to allow SIPs to act as the header without the need for additional structural elements.**
   - **3.8. SIP roofs can cantilever past walls to provide overhangs.**
   - **3.9. SIPs can act as their own header minimizing costs and maximizing thermal performance.**
   - **3.10. Wall SIPs may require a cap plate to meet high point load conditions.**
4. SIP Sizes
5. SIP Shop Drawings
6. SIP Fabrication
7. SIP Installation
8. SIP Roof and Wall Assemblies
9. SIP Electrical
10. SIP Plumbing

SIP DESIGN-BP 3:

Structural Capabilities

SIP DESIGN-BP 3.1:
Manufacturers publish construction manuals and load design charts that can be accessed to understand structural capacities.

When a project does not meet the prescriptive requirements of the International Residential Code (IRC), Section R301.1.3 Engineered design applies. Section R301.1.3 Engineered design of the 2018 IRC states:

> *Where a building of otherwise conventional construction contains structural elements exceeding the limits of Section R301 or otherwise not conforming to this code, these elements shall be designed in accordance with accepted engineering practice. The extent of such design need only demonstrate compliance of nonconventional elements with other applicable provisions and shall be compatible with the performance of the conventional framed system. Engineered design in accordance with the International Building Code is permitted for buildings and structures, and parts thereof, included in the scope of this code.*

Since their inception back in the 1930's, SIPs (in former times also known as stress skin panels) have been well-tested and proven reliable. APA – the Engineered Wood Association published its 24-page *Structural Insulated Panels Product Guide* and the *ANSI/APA-PRS610.1-2018 Standard for Performance-Rated Structural Insulated Panels in Wall Applications* which can be found for free download on both the APA (www.apawood.org) and the SIPA (www.sips.org) websites.

The U.S. Department of Agriculture's Forest Products Laboratory has published numerous test reports as shown below. The Builder's Guide to Structural Insulated Panels (SIPs) by Building Science Corporation is available at www.sips.org. Numerous individual company code evaluation reports, load charts and construction manuals are also available to help the design professional design SIPs in accordance with accepted engineering practice.

- *Lateral Load Performance of SIP Walls with Full Bearing FPL-GTR-251*
- *Lateral Load Performance of Structural Insulated Panel (SIP) Diaphragms FPL-RP-700*
- *Creep Behavior of Structural Insulated Panels (SIPs) Results from a Pilot Study FPL-RN-0332*
- *Evaluation of Creep Performance of Structural Insulated Panels (SIPs) Phase 2 FPL-RP-697*
- *SIP Shear Walls Cyclic Performance of High-Aspect-Ratio Segments and Perforated Walls FPL-RP-682*
- *Performance of Structural Insulated Panel Walls under Seismic Loading FPL RP 704*
- *Seismic Evaluation of Structural Insulated Panels in Comparison with Wood-Frame Panels*
- *APA Report T2011-73 Durability Testing for Structural Insulated Panels (SIPs)*

While the above-mentioned resources are primarily used in North America, ISO standards prevail throughout the rest of the globe. Global ISO Standards for SIP walls and roofs are available for purchase at www.iso.org.

- *ISO 18402 Timber Structures - Structural Insulated Panel Roof Construction - Test Methods*
- *ISO 22452 Timber Structures - Structural Insulated Panel Walls - Test Methods*

SIP manufacturers' load design charts, evaluation reports and construction manuals provide design professionals with the resources to confidently design structures utilizing SIPs.

SIP DESIGN-BP 3.2:
SIPs have been included in the IRC since the 2007 supplement to the 2006 IRC.

SIPs can be used for the construction of homes in accordance with the prescriptive requirements of the IRC if they meet the general applicability limits of the IRC. These limitations, which cover the large majority of residential construction, are that the structure has a footprint of 40 feet by 60 feet or less, is two stories or less in height above the basement, and has a maximum building height of 35 feet. Structures adhering to these parameters do not require engineering since they follow prescriptive requirements. However, buildings that exceed these limitations would require specific project engineering.

SIPs were first introduced into the 2007 supplement of the 2006 IRC under Section R614, Structural Insulated Panel Wall Construction. This was changed to Section R613 of the 2009 IRC and is under Section R610 of the 2018 IRC. Section R610.1 General says:

> *Structural insulated panel (SIP) walls shall be designed in accordance with the provisions of this section. When the provisions of this section are used to design structural insulated panel walls, project drawings, typical details and specifications are not required to bear the seal of the architect or engineer responsible for design, unless otherwise required by the state law of the jurisdiction having authority.*

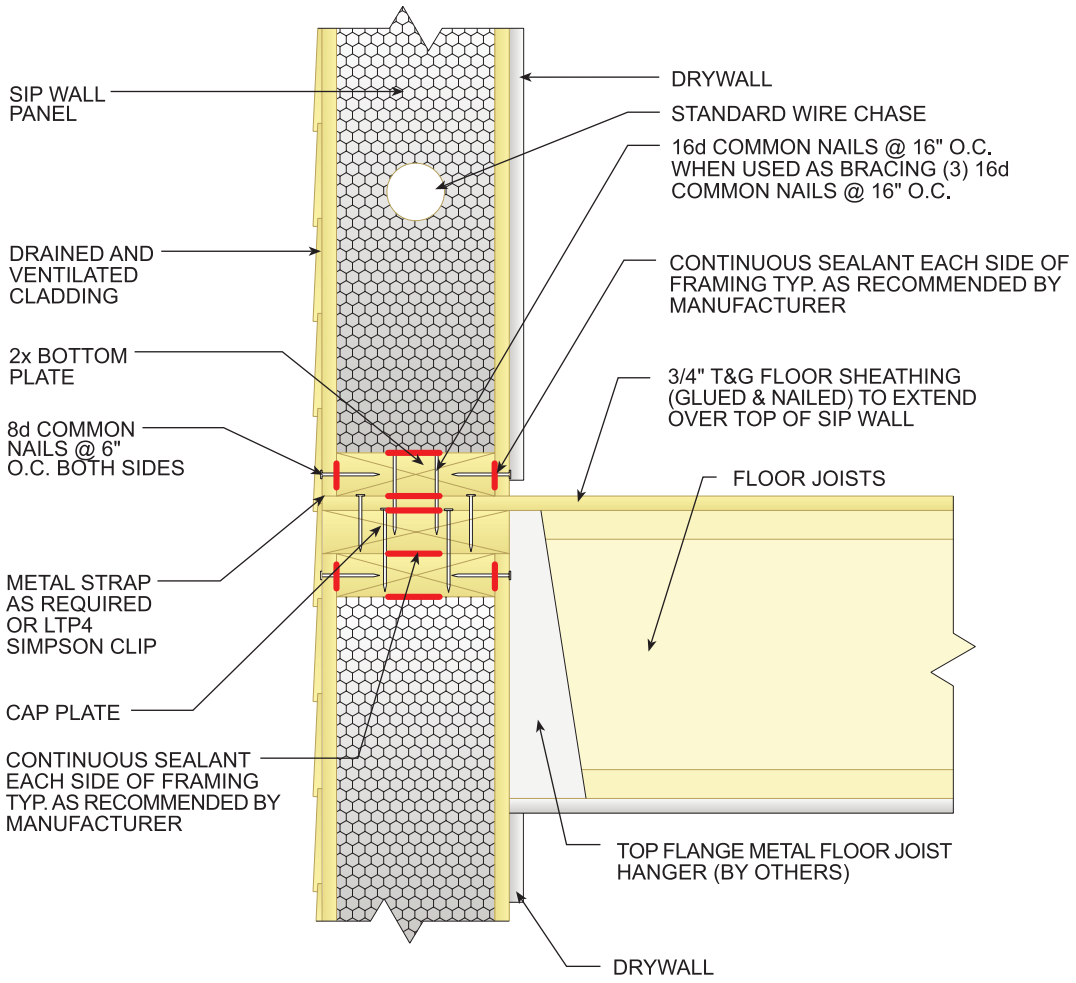
One of the most complicated aspects of residential design and construction is determining the amount of wall bracing required to resist lateral loads induced by wind loads and seismic events. A key benefit of using the IRC is that it provides design professionals and builders with detailed information regarding the required wall bracing for residential construction. Section R602.10 establishes traditional stick frame construction using continuous wood structural panel sheathing (bracing Method CS-WSP) as the base to which all other wall framing systems are compared. Section R610.5.5 Wall Bracing says that "*SIP walls shall be braced in accordance with Section R602.10. SIP walls shall be considered continuous wood structural panel (bracing Method CS-WSP) for purposes of computing required bracing*."

Being able to equate SIP construction with traditional stick framing by applying the provision of Section R610.5.5 greatly simplifies the design professional's and builder's role in using SIPs in residential wall construction. SIPA Technical Bulletin No. 8 *Wall Aspect Ratios for SIPs* provides additional detailed prescriptive wall bracing guidance based on the IRC.

The IRC also provides numerous Figures showing installation recommendations for SIP walls. An example for a SIP Wall-to-Wall Platform Connection is shown in Detail 3.1 below. Note that the graphic details may differ based on geography or other design requirements or best practices.

DETAIL 3.1:

IRC FIGURE R610.5(5) SHOWING SIP WALL-TO-WALL PLATFORM FRAME CONNECTION



FOR SI: 1 inch = 25.4 mm.
Note: Figures illustrate SIP-specific attachment requirements. Other connections shall be made in accordance with Tables R602.3(1) and (2) as appropriate.

IRC Table R610.5(1), which is too large to be reproduced here, provides the minimum thickness of SIP walls required to support a SIP or light frame roof only (one story). IRC Table R610.5(2) provides the minimum thickness of SIP walls required to support a SIP or light frame story and roof (two stories). Both tables are for building widths of 24 feet to 40 feet with wall heights of 8, 9 and 10 feet. Wind loads are ultimate design wind speeds ranging from 110 mph to 140 mph for one-story construction and 110 mph to 130 mph for two-story construction with ground snow loads ranging from 20 psf to 70 psf for both single and two-story houses.

Tables are also provided by the IRC giving additional design information. Table R610.8 provides maximum spans for 11-7/8-inch or deeper SIP headers for two different load conditions (supporting roof only and supporting roof and one story), for ground snow loads ranging from 20 psf to 70 psf, and for building widths ranging from 24 feet to 40 feet.

Tables R610.5(1), R610.5(2) and R610.8 are also available in the *APA/SIPA Structural Insulated Panels Product Guide*, which provides the minimum thickness of SIP walls required to support SIP or light frame roofs and can be downloaded as an electronic pdf file from APA or SIPA.

SIP DESIGN-BP 3.3:
Structural capacities are recognized for compliance with Model Building Codes in evaluation reports from ICC-ES, ICC NTA, Intertek or IAPMO.

While SIPs are recognized in the IRC as discussed in SIP DESIGN-BP 3.2, they are not directly recognized in the IBC. But both the IBC and IRC allow for products and construction methods not specifically contained within these codes to be recognized as meeting their structural requirements, provided that these products and construction methods are subjected to testing and evaluation by third-party evaluation agencies. These agencies themselves must be recognized to conduct product and system evaluations by the Authority Having Jurisdiction (AHJ).

The evaluations by the Third-Party Testing and Listing Agencies result in published “Evaluation Reports.” This Evaluation Report process gives assurance to Building Officials that the construction method tested and evaluated is in compliance with the structural requirements of the evaluated Code. ICC Evaluation Services, ICC NTA, Intertek and IAPMO are examples of the Third-Party Testing and Listing Agencies providing evaluation services to the construction industry.

SIP DESIGN-BP 3.4:
The structural capacity of SIPs changes with height/length, thickness and connection method,

and

SIP DESIGN-BP 3.5:
SIP roofs offer great design flexibility to span long distances. SIPs can be combined with structural splines to span up to 24 feet. Exterior walls, beams, purlins, interior partitions, timber frame, or trusses constructed of either wood or steel are required to support a SIP roof.

Load capacities vary from manufacturer to manufacturer for different SIP thicknesses, and spline types and manufacturer-specific code listing reports should be used to verify these capacities.

SIPs can be manufactured in sizes up to 8 feet wide and 24 feet long and in varying nominal thicknesses ranging from 4-1/2 inches to 15 inches. This versatility in sizes offers the design professional a wide range of options to satisfy virtually any design situation. The 4-1/2-inch and 6-1/2-inch-thick SIPs are typically used for walls to resist both out-of-plane and in-plane forces induced by gravity loads and wind or seismic loads. Thicker SIPs are typically used for roofs and floors.

As an example, in accordance with the SIPA code listing report, a 6-1/2-inch-thick SIP can be used to span 8 feet carrying 56 psf for floors at a deflection limit of L/360 which is adequate for most residential floor applications. The same thickness SIPs can carry up to 80 psf for roofs at a deflection limit of L/180 which is adequate for most roof snow load situations in the U.S. The use of a 12-1/4-inch-thick SIP can carry up to 106 psf for an 8-foot span for either a floor or roof application.

Floors using traditional stick framing with a relatively thick 1-3/32-inch wood structural panel (WSP) sheathing would limit the span or spacing of support members to be a maximum of 4 feet on center to carry 55 psf as compared to the 6-1/2-inch SIP with a support spacing of 8 feet. Using a more common WSP thickness of 13/32-inch would require the support spacing members to be at a maximum of 2 feet on center for a floor to carry 100 psf as compared to the 8-foot spacing of supports for the 12-1/4-inch SIP to carry a 106 psf load. Similar comparisons can be made for roofs, demonstrating that the use of SIPs compared to stick framing requires far fewer support members to carry equivalent loads.

SIPs' longer span capabilities combined with the larger length and width combinations (jumbo panels) greatly reduce the construction time. Support members for SIPs can be exterior walls, beams, purlins, timber framing, trusses or other conventional framing members often associated with stick framing.

A common method for joining individual SIPs is the use of a surface or box/block spline. Both methods are easy to install in the field and do not introduce a thermal break as is typical for lumber studs used in stick framing.

However, dimensional lumber is used in conjunction with SIPs for some specific connection details. For example, solid chord members using 2x dimensional lumber are required at each end of each SIP shear wall segment. For SIPs used as horizontal diaphragms subjected to wind or seismic loading, a 2x dimensional lumber boundary member is used.

For longer span roof applications, up to 24 feet, lumber splines or I-joist splines are typically used. The width of these SIPs is typically limited to 4 feet. The design professional is advised to verify span/load capacities from manufacturer-specific design literature and code listing reports for these applications.

SIP DESIGN-BP 3.6:
SIPs are compatible with interior conventional framing.

SIPs are generally used for all exterior framing of the structure but can also be used for interior walls. Typically, the interior walls are traditional stick framing. This method works well in conjunction with SIPs if the proper methods of connection are followed.

As an example, when there is an intersecting stick frame wall with a SIP wall, attachment can be made from the outside of the SIP using long panel screws through the panel into the stick frame wall. Stick framed walls can also be used to support spans of the SIP roof panels if the wall is designed properly for the gravity load and to the required height for the wall.

Factory-cut electrical chases in the SIPs make running wiring at the project site easy, but good SIP construction practice is to concentrate electrical wiring needs in open-framed interior walls. In ceiling applications, it is recommended that furring strips be used to conceal wiring chases outside of the SIP. See ***DESIGN-BP 9: SIP Electric*** for further information.

Plumbing is best to be pre-planned for interior stick frame walls. If there is a need for a vent in an exterior wall, consider using an island vent or mechanical vent system to redirect that to the interior stick frame wall. Always check with local code officials for acceptance of these methods.

As always, consult with your SIP manufacturer for specific details.

SIP DESIGN-BP 3.7:
Point loads may dictate the need for additional structural components to be embedded internally. Avoid point loads over openings to allow SIPs to act as the header without the need for additional structural elements.

The SIP walls transfer the axial loads of a structure by fully bearing on the supporting element or structure. If the compressive resistance of the OSB facer is exceeded, additional compression elements must be used to adequately transfer the design loads. These additional compression elements are typically comprised of dimensional sawn lumber and engineered wood products. Steel may be used in extreme loading conditions.

If the designer can minimize point loading conditions over openings, the SIP wall may be able to act as the header without the addition of other structural elements in the SIP wall above the opening. This provides for a more economical SIP wall design.

SIP DESIGN-BP 3.8:
SIP roofs can cantilever past walls to provide overhangs.

One of the key architectural design elements used to help protect exterior walls from exposure to rain is to provide roof overhangs on gable end walls or on eave applications. SIPs can easily be cantilevered past exterior walls to provide these overhangs. The use of SIPs to create the overhangs is advantageous because it speeds the construction of the project and saves labor costs associated with hand framing these overhangs such as with conventional stick framing.

The allowable overhang is controlled by the depth of the SIP, the orientation of the SIP with respect to the exterior wall, the type of spline used, and the load to be carried. Some SIP manufacturers provide recommended cantilever overhang spans for their products in their technical literature. Overhang spans can range from 1 foot to 4 feet when using a surface spline or box/block spline.

As a general guideline, SIPs can be used to create overhangs of up to 2 feet when the SIP is installed with the strong axis parallel to the support wall. If the SIP is installed with the strong axis perpendicular to the support wall, longer overhangs can be achieved with proper design considerations. Designs are controlled by live load deflection and total load deflection and assume that the SIPs are installed with a back span equal to twice the overhang span.

Longer overhangs are typically achieved by using SIPs that utilize double 2x's or wood I-joist as the spline mechanism. These longer overhang applications are created when the SIPs are perpendicular to the support wall and the SIPs extend back onto the roof to a support. Consult with SIP manufacturer for specific guidelines.

SIP DESIGN-BP 3.9:
SIPs can act as their own header minimizing costs and maximizing thermal performance.

One of the inherent advantages of a SIP is that the wall can be used as a header to carry loads over openings in the wall. This not only minimizes construction costs but also minimizes thermal bridging that occurs when lumber structural support elements are required to act as a header to carry loads over an opening. The structural capability of the SIP wall to function as a header is a function of the opening size, the load to be carried, and the depth of the panel above the opening.

Some manufacturers provide header span tables in their code listing reports or in other technical literature. Table R610.8 of the 2018 IRC, excerpted in Table 3.1, provides recommendations for SIP header spans.

TABLE 3.1:
EXCERPT OF IRC TABLE R610.8

MAXIMUM SPANS FOR 11-7/8-INCH OR DEEPER SIP HEADERS (feet)[a]

LOAD CONDITION	GROUND SNOW LOAD (psf)	Building width (feet)[b]				
		24	28	32	36	40
Supporting roofc,d only	20	4	4	4	2	2
	30	4	4	2	2	2
	50	2	2	2	2	2
	70	2	2	2	DR	DR
Supporting roof and one story	20	2	2	DR	DR	DR
	30	2	2	DR	DR	DR
	50	2	DR	DR	DR	DR
	70	DR	DR	DR	DR	DR

a. Design assumptions:
Maximum deflection criteria: L/240.
Maximum roof dead load: 10 psf.
Maximum ceiling dead load: 5 psf.
Maximum ceiling live load: 20 psf.
Maximum second floor dead load: 10 psf.
Maximum second floor live load: 30 psf.
Maximum second floor dead load from walls: 10 psf.
Maximum first floor dead load: 10 psf.
Wind loads based on Table R301.2(2).
Strength axis of facing material applied horizontally.
DR = Design Required.

b. Building width is in the direction of horizontal framing members supported by the header.

c. The table provides for roof slopes between 3:12 and 12:12.

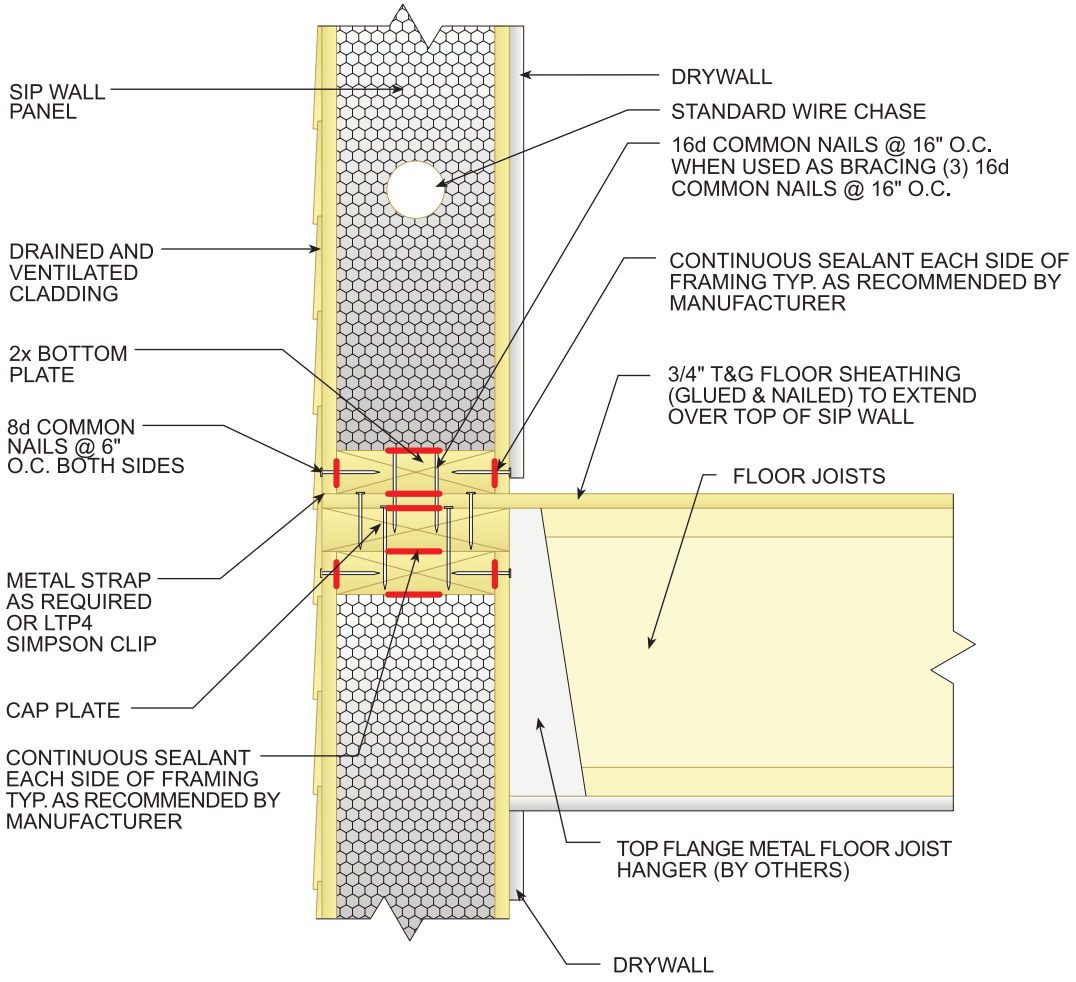
d. The maximum roof overhang is 24 inches (610 mm).

In cases where a concentrated load is placed over an opening or the design loads exceed the capacity of the panel header, it is necessary to introduce built-up lumber or engineered wood framing to carry these loads. For typical situations, SIPs require the built-up headers to be placed directly beneath the top plate of the wall and the trimmer studs to extend up to the underside of the header. If required by the structural design, king studs can be added and attached to the trimmer studs. By using this methodology, the built-up header transfers the loads to the trimmer studs through bearing, and the SIP wall below the header transfers the wind loading to the king studs attached to the trimmer studs.

SIP DESIGN-BP 3.10:
Wall SIPs may require a cap plate to meet high point load conditions.

SIP wall capacities are typically given in plf (pounds per lineal foot). This type of load description, plf, works well to determine the SIP wall capacity on a global scale. However, the designer is cautioned to review the load path from structural elements that are transferring load to the SIP wall. The localized loading that these structural elements transfer to the SIP wall may exceed the capacity of the wall and require the addition of a cap plate to provide additional localized capacity at the load transfer point. Refer to Detail 3.2 showing the cap plate on the lower level wall supporting the top flange hanger.

DETAIL 3.2:
2ND FLOOR CONNECTION DETAILS – TOP FLANGE HANGER



Glossary of Terms

ANSI: American National Standards Institute (www.ansi.org) is a private, not-for-profit organization dedicated to supporting the U.S. voluntary standards and conformity assessment system and strengthening its impact, both domestically and internationally.

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.

ASHRAE: the American Society of Heating, Refrigerating and Air-Conditioning Engineers (www.ashrae.org) is an American professional association seeking to advance heating, ventilation, air conditioning and refrigeration systems design and construction.

Cap plate: lumber ripped to the width of the panel that bears on the top of both facers of the SIP below. Not a top plate; it bears on the top plate. For illustration, refer to Details 3.1 and 3.2 in *SIP Design Best Practices 3: SIP Structural Capabilities*.

CLT: cross-laminated timber, an engineered wood product.

Dimensional lumber: wood lumber that is cut to pre-defined, standard sizes (e.g., 1-inch x 4-inch, 2-inch x 4-inch, etc.).

Engineered lumber: wood products which are manufactured by binding or fixing the strands, particles, fibers, or veneers, or boards of wood, together with adhesives or other methods of fixation, to form composite material. Examples include glulam, Parallam, CLT, I-joist, LVL and rim board.

HERS: Home Energy Rating System. The HERS index measures energy consumption from heating, cooling, water heating, lights, and some appliances. The lower the index, the less energy a building is consuming. A HERS rating of zero signifies a net-zero energy building.

HVAC: heating, ventilation and air conditioning.

IAQ: indoor air quality.

IAPMO: International Association of Plumbing and Mechanical Officials (www.iapmo.org) works in concert with government and industry to implement comprehensive plumbing and mechanical systems around the world.

IBC: the International Building Code is a model building code developed by the International Code Council (ICC). The code provisions are intended to protect public health and safety while avoiding both unnecessary costs and preferential treatment of specific materials or methods of construction.

ICC-ES: International Code Council Evaluation Service (www.icc-es.org), a subsidiary of the International Code Council and a nonprofit, limited liability company that does technical evaluation reports of building products, components, methods and materials.

ICC NTA, LLC: a subsidiary of the International Code Council acquired in 2019 providing third-party testing, inspection, code evaluation, certification and plan review (www.ica-nta.org).

I-joist: strong, lightweight, “I” shaped engineered wood structural members used extensively in residential and light commercial construction projects.

Intertek: a multinational assurance, inspection, product testing and certification company headquartered in London, United Kingdom.

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.

ISO: International Organization for Standardization, a standard-setting body composed of representatives from various national standards organizations, promoting worldwide proprietary, industrial and commercial standards.

LVL: laminated veneer lumber, an engineered wood product.

OSB: Oriented strand board (OSB) is a type of engineered wood structural panel formed by adding adhesives and then compressing layers of wood strands.

PLF: pounds per lineal foot.

SIPA: Structural Insulated Panel Association (www.sips.org), a non-profit trade association representing manufacturers, suppliers, dealer/distributors, design professionals and builders committed to providing quality structural insulated panels for all segments of the construction industry.

SIPs: Structural Insulated Panels, a high-performance building component for residential and light commercial construction.

Spline: connection system used to connect two panels together at vertical, in-plane joints. Many different spline systems are available including box/block, surface, I-joist, dimensional lumber and engineered lumber.

Thermal bridging: the movement of heat across an object that is more conductive than the materials around it. The conductive material creates a path of least resistance for heat. Thermal bridging can be a major source of energy loss in homes and buildings.

Top plate: a horizontal member positioned between the SIP facers above the foam. Sits under the cap plate. For illustration, refer to Details 3.1 and 3.2 in *SIP Design Best Practices 3: SIP Structural Capabilities*.

WSP: wood structural panel; plywood or OSB facers used to laminate to foam, to form a composite SIP.

Written and compiled by SIP Industry Professionals:

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- James Hodgson – Premier Building Systems
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- Joe Pasma, PE – Enercept
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Structural Insulated Panel Association Staff:

- Jack Armstrong, Executive Director
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SECTION 6:
SIP Design BP 4: SIP Sizes

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SIP DESIGN-BP 4:

SIP Sizes

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**
   - **4.1. Use support spacings of 4', 8', 12', 16', etc. to maximize efficiency of SIP layout and to reduce costs.**
   - **4.2. SIP roofs are supported by structural elements, either parallel or perpendicular to the ridge. Orientation is a function of the support elements and the spacing.**
   - **4.3. SIPs provide for long spans which may eliminate some conventional roof supports.**
   - **4.4. Wall thickness will generally increase when using SIPs over conventional construction. Extension jambs may be required for window and door detailing.**
5. SIP Shop Drawings
6. SIP Fabrication
7. SIP Installation
8. SIP Roof and Wall Assemblies
9. SIP Electrical
10. SIP Plumbing

SIP DESIGN-BP 4:

SIP Sizes

SIP DESIGN-BP 4.1:

Use support spacings of 4’, 8’, 12’, 16’, etc. to maximize efficiency of SIP layout and to reduce costs, and SIP DESIGN-BP 4.3: SIPs provide for long spans which may eliminate some conventional roof supports.)

SIPs are commonly manufactured in nominal 4-1/2-inch, 6-1/2-inch, 8-1/4-inch, 10-1/4-inch and 12-1/4-inch thicknesses. The 4-1/2-inch and 6-1/2-inch-thick SIPs are typically used for walls. The thicker SIPs are typically used for floors and roofs. SIPs can be manufactured in sizes ranging from 4’ x 8’ to 8’ x 24’. This versatility in sizes offers the design professional a wide range of options to satisfy virtually any design situation including spanning from 4 feet to 24 feet without intermediate supports as are often required for other stick framing systems.

As examples, in accordance with the SIPA ICC-NTA code listing report, a 6-1/2-inch-thick SIP can be used to span 8 feet carrying 56 psf for floors at a deflection limit of L/360 which is adequate for most residential floor applications. The same thickness SIPs can carry up to 80 psf for roofs at a deflection limit of L/180 which is adequate for most roof snow load situations in the U.S. The use of a 12-1/4-inch-thick SIP can carry up to 106 psf for an 8-foot span for either a floor or roof application.

SIPs used in roofs offer even greater design flexibility to span long distances. For longer span roof applications up to 24 feet, lumber splines or I-joist splines are typically used. Sizes for these SIPs are typically limited to 4’ x 24’. A single SIP that is 4’ x 24’ in cross section used in a roof application covers 96 sq. ft. with no intermediate supports required. A roof using traditional lumber or I-joist framing members would require multiple framing members spaced 16 inches or 24 inches on center to accomplish the same area of roof coverage. Thus, the use of a single SIP offers considerable savings in labor/installation costs.

The design professional is advised to verify span/load capacities from manufacturer-specific code listing reports and other design literature for these applications, as load capacities vary from manufacturer to manufacturer for different SIP thicknesses and spline types.

SIP DESIGN-BP 4.2:
SIP roofs are supported by structural elements, either parallel or perpendicular to the ridge. Orientation is a function of the support elements and the spacing.

SIP roofs can offer great design flexibility. SIPs need to be supported in either a single span or multi-span design, typically a minimum of 1-1/2-inch of bearing required. Exterior walls, glulam beams (ridge and mid-span), purlins, interior partition walls, timber frame, or roof trusses constructed of either wood or steel can be used to support SIPs. This allows the SIPs to be oriented in either a parallel or a perpendicular direction to the ridge. SIPs can span up to 24 feet when combined with structural splines (I-joists, double 2x or LVLs). To utilize the large 8' x 24' SIPs, design the support system using the SIP manufacturer's load charts to ensure SIP spans are achievable. SIP support in valley or hip situations can be achieved by incorporating structural members inside the SIPs for shorter spans or using support under the SIPs for longer spans and to simplify installation.

SIP DESIGN-BP 4.3:
SIPs provide for long spans which may eliminate some conventional roof supports.

Please see commentary above under SIP DESIGN-BP 4.1.

SIP DESIGN-BP 4.4:
Wall thickness will generally increase when using SIPs over conventional construction. Extension jambs may be required for window and door detailing.

Typically, SIP wall nominal thicknesses are 4-1/2-inch and 6-1/2-inch. The EPS core thickness for these nominal wall thicknesses typically correspond to dimensional lumber sizes of 3-1/2-inch and 5-1/2-inch. The typical OSB facer used with SIPs is 7/16-inch in thickness. This equates to a SIP wall thickness that is marginally thicker than the conventionally framed wall (without continuous insulation "ci") due to the second layer of OSB used in the SIP wall.

What this means for the design professional is that jamb thicknesses for window and door openings in a SIP wall will need to be nominally 7/16-inch thicker than for a conventionally framed wall. Window and door manufacturers can accommodate this additional thickness of the wall without any issues, but they need to be aware of this condition so they can supply the proper size extension jambs.

If OSB thicknesses different than 7/16-inch are used for the SIP wall panel facers, the corresponding thickness of the wall will vary. The design professional is advised to consult with the specific SIP manufacturers selected for the project to verify the overall SIP wall thickness based on the specific project requirements.

Glossary of Terms

Continuous Insulation (ci): insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior, exterior, or is integral to any opaque surface of the building envelope.

Glulam: an engineered wood.

OSB: oriented strand board, an engineered wood product.

PSF: pounds per square foot pressure unit

SIPA: Structural Insulated Panel Association (www.sips.org), a non-profit trade association representing manufacturers, suppliers, dealer/distributors, design professionals, and builders committed to providing quality structural insulated panels for all segments of the construction industry.

SIPs: Structural Insulated Panels, a high-performance building component for residential and light commercial construction.

Spline: connection system used to connect two panels together at vertical, in-plane joints. Many different spline systems are available including box/block, surface, I-joist, dimensional lumber and engineered lumber.

Structural Splines: I-joist, double 2x, or engineered lumber like LVL.

Structural Members: a load-carrying element.

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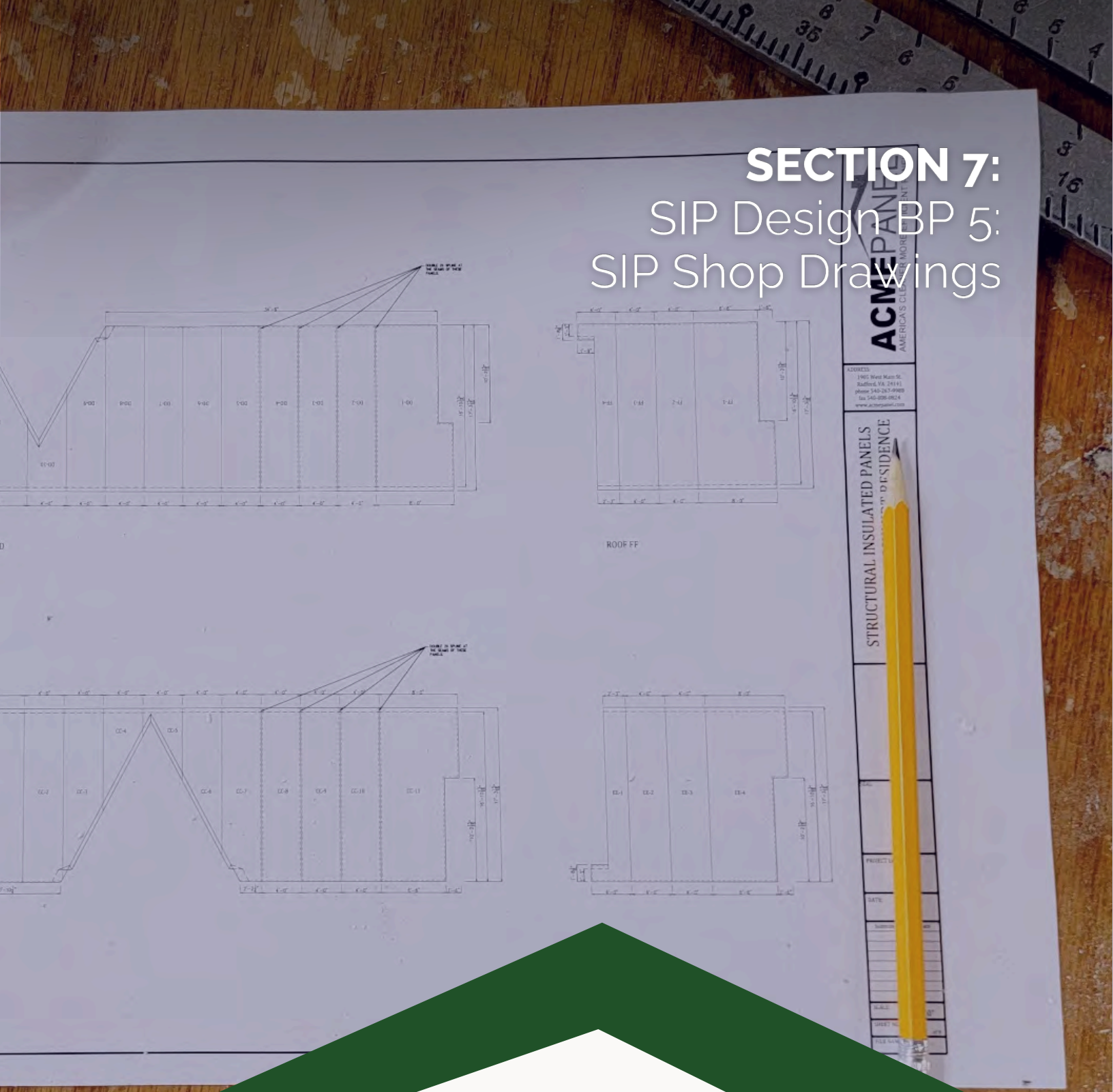
SECTION 7:
SIP Design BP 5: SIP Shop Drawings



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SIP DESIGN-BP 5:

SIP Shop Drawings

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
5. **SIP Shop Drawings**
   - **5.1. Depending on complexity of design, need for engineering, permitting, and possible revisions, the development of SIP shop drawings is a process that relies on engagement from those reviewing these drawings on behalf of the building owner.**
   - **5.2. SIP shop drawings are provided for client review and approval.**
   - **5.3. Let the SIP manufacturer do the work of establishing initial SIP layout and associated details.**
   - **5.4. Both SIP wall skins (inner and outer facings) must fully bear on the support deck without any overhang. Detail accordingly.**
6. SIP Fabrication
7. SIP Installation
8. SIP Roof and Wall Assemblies
9. SIP Electrical
10. SIP Plumbing

SIP DESIGN-BP 5:

SIP Shop Drawings

SIP DESIGN-BP 5.1:

Depending on complexity of design, need for engineering, permitting, and possible revisions, the development of SIP shop drawings is a process that relies on engagement from those reviewing these drawings on behalf of the building owner.

Local building code jurisdictions may require design-professional-stamped architectural building plans for all structures. These plans may be prepared by an architect, engineer or building designer. The plans may range from simple 2D drawings to complex 3D drawings and contain plan views, elevations and installation details necessary to complete the construction of the building in compliance with the applicable codes. In many instances the architectural plans may include prefabricated building components such as SIPs which require shop drawings. The SIP shop drawing process (similar to manufactured trusses) may require weeks of planning prior to the fabrication and delivery of the SIPs, depending on complexity of project and customer approval processes. This upfront planning ensures smooth installation with minimal field changes, resulting in reduced installation time and waste.

SIPA manufacturers use architectural drawings as the basis to create a set of SIP shop drawings which will be used by the manufacturer to fabricate SIPs to exacting standards. In order to ensure that these SIP components will fit precisely, meet all architectural plan requirements and optimize construction time, the importance of the drawing review process, by either the owner or an authorized representative of the owner, cannot be overstated. The old adage, “measure twice, cut once” cannot be more appropriate than to the SIP shop drawing review. SIP shop drawings specify SIP size, layout, assembly details and installation specifications. The SIP manufacturer is best positioned to factor in material yield, ease of installation, cost of fabrication, structural requirements and building design intent when designing the SIP panel layouts. When it comes to designing and building a high-performance SIP structure, the upfront investment in the SIP drawing review will prove to be the best investment, resulting in a faster install and a reduction in the manpower needed on the jobsite.

A detailed description of the process associated with the preparation, review and approval of these SIP shop drawings is provided in SIP DESIGN-BP 5.2.

SIP DESIGN-BP 5.2:

SIP shop drawings are provided for client review and approval.

SIP manufacturers will use the architectural construction drawings (see Image 5.1) provided by the client/customer to create SIP shop drawings.

IMAGE 5.1:

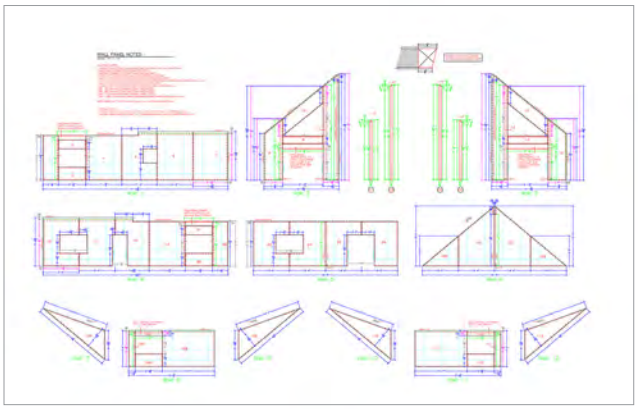
ARCHITECTURAL CONSTRUCTION DRAWINGS

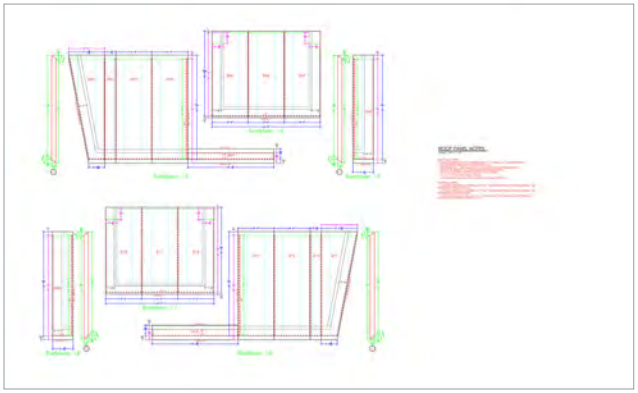
The SIP shop drawing is the SIP manufacturer's drawn version of information shown in the architectural construction documents. This usually starts with constructing a 3D model of the project as seen below in Image 5.2.

IMAGE 5.2:
3D MODEL SIP SHOP DRAWINGS

The SIP shop drawings normally show more detail (see Image 5.3) than the architectural construction documents regarding the SIPs. The SIP shop drawing is drawn to explain the fabrication and/or installation of the SIPs to the SIP manufacturer's production crew and the contractor's installation crews. The information shown on the SIP shop drawing is usually very different from that of the designer's or architect's construction drawing. The SIP shop drawings' primary emphasis is on the SIP product and excludes notation concerning other products and installations unless integration with the SIP is necessary.

IMAGE 5.3:
SIP SHOP DRAWINGS





It is very important that the client/customer review the SIP shop drawings prior to manufacture of the SIPs for dimensional accuracy, rough opening dimensions and placement, panel thicknesses, roof pitch and other items pertinent to the project.

The customer will be asked to “red line” or comment on the SIP shop drawings as necessary and to approve the SIP shop drawings before manufacturing is initiated. Prompt return of the approved SIP shop drawings ensures the timely delivery of materials. Production lead times vary by manufacturer, time of year, and the size and complexity of the project.

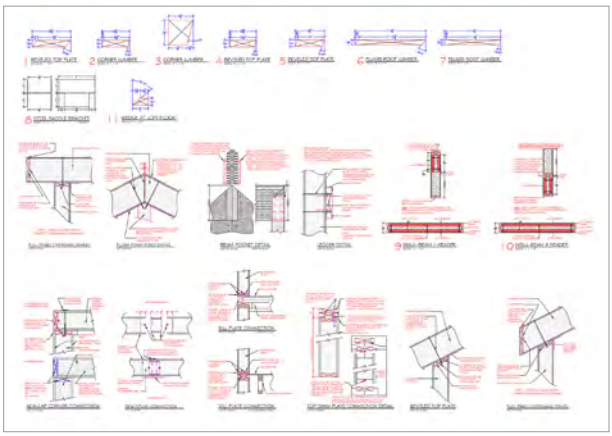
Approval of the SIP shop drawings usually consists of signing and dating an approval stamp that is placed on each sheet of the SIP shop drawings. A sample approval stamp is shown below in Image 5.4.

IMAGE 5.4:
SIP MANUFACTURER APPROVAL STAMP

SIP DESIGN-BP 5.3:
Let the SIP manufacturer do the work of establishing initial SIP layout and associated details.

Once you have chosen the SIP manufacturer for the project, they will work with the architectural construction drawings as described in SIP DESIGN-BP 5.2 to create a set of SIP shop drawings. By allowing the SIP manufacturer to create the SIP shop drawings, they can utilize their details and best practices in the project (see Image 5.5). Through this process, they will be looking at the details needed to make the project a success.

IMAGE 5.5:
SIP SHOP DRAWING DETAILS



Having accurate window and door rough openings can save time. This way all openings can be created and headers, if necessary, can be sized. Columns for point loads like girder trusses, glulam beams or other structural loads are located to assure proper transfer of loads.

Once the SIP shop drawings are completed and they have gone through the process of client review and approval, then, if necessary, drawings are sent to a structural engineer for approval.

This process can save time once all materials show up on the jobsite (see Image 5.6) since the structural components have been taken into account through the SIP shop drawing process. The time invested during the SIP shop drawing process enables labor savings during installation.

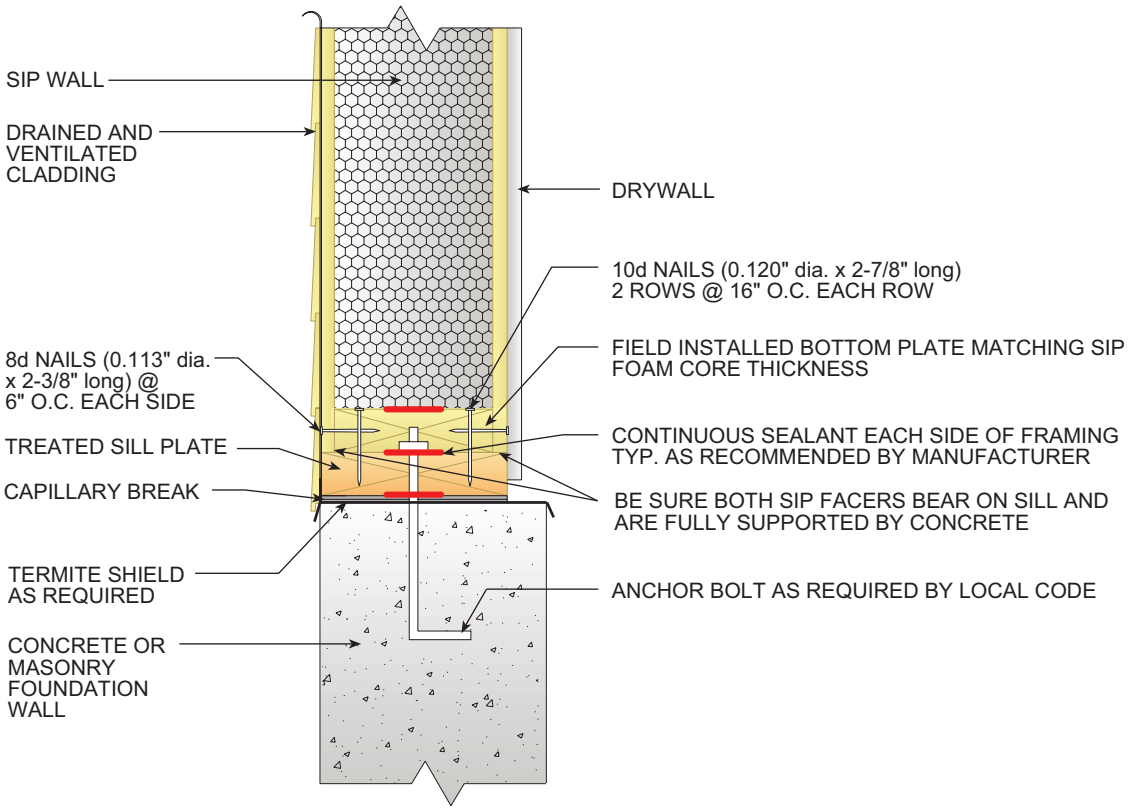
IMAGE 5.6:
SIPS STAGED ON JOBSITE

SIP DESIGN-BP 5.4:
Both SIP wall skins (inner and outer facings) must fully bear on the support deck without any overhang. Detail accordingly.

In order to transfer gravity loads, in-plane loads and out-of-plane lateral loads in SIP wall construction, the OSB facers of the SIP must bear directly on the members supporting them. This is based on extensive research conducted by SIPA and is unlike conventional wood frame construction where the structural sheathing does not bear directly on the support members because the studs in the walls carry the gravity loads and out-of-plane lateral loads.

Bearing of the OSB facers is achieved by following Figures 4 and 13, reproduced below, from ***SIPs Basic Connection Details****. Details illustrating full bearing of both facers are provided in ***SIPs Basic Connection Details*** and in manufacturers' literature, to guide design professionals in preparing their architectural construction drawings to include this detail.

*Available for free download on the SIPA website, under Resources, Installation.



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.

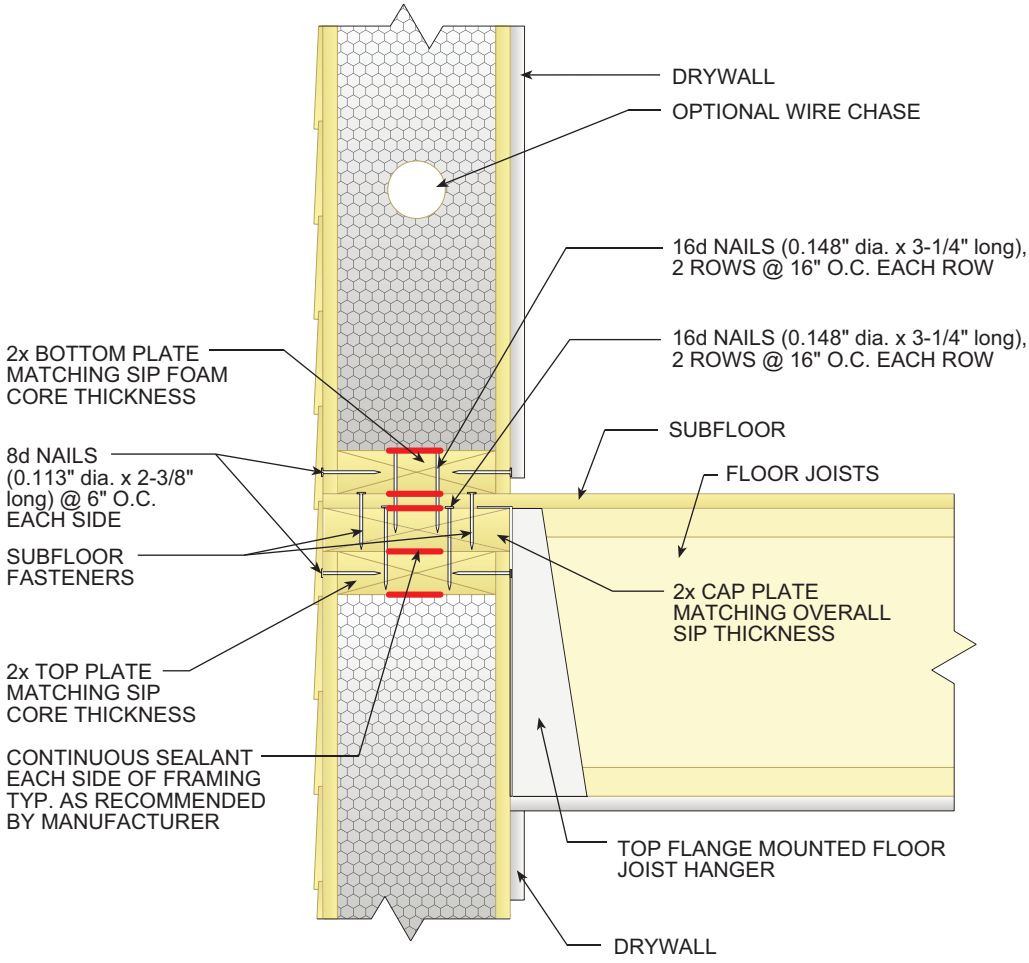
VERIFY NAIL SPACING PER MANUFACTURER SPECS/CODE LISTING

FOUNDATION CONNECTIONS

SIP WALL ON FOUNDATION

Fig. 4

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



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

2ND FLOOR CONNECTION DETAILS

HANGING FLOOR JOIST SYSTEM

Fig. 13

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

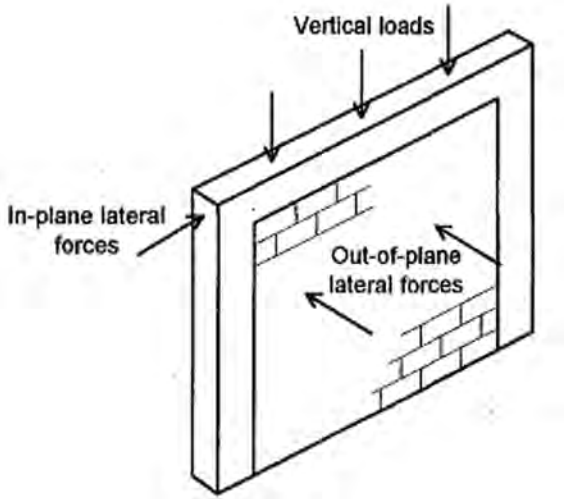
Glossary of Terms

Architectural drawings: also called construction drawings (used interchangeably), architectural construction drawings are made according to a set of conventions, which include particular views (floor plan, section, etc.), sheet sizes, units of measurement and scales, annotation and cross referencing. These are not the same as SIP shop drawings.

CNC machining: Computer Numerical Control (CNC) machining is a manufacturing process is which pre-programmed computer software dictates the movement of factory tools and machinery.

Gravity loads: also called vertical loads, gravity loads are those forces that are applied perpendicular to the roof or floor system (i.e., perpendicular to the ground). These are separated into two categories: dead loads and live loads.

In-plane load: a load acting horizontally to the SIP; e.g., wind load or earthquake load applied to the wall or roof parallel to the wall or roof surface.



Out-of-plane load: a load acting perpendicular to the wall; e.g., wind load applied on the wall is an out-of plane-load.

SIP shop drawings: drawings showing more detail than the architectural construction documents regarding the SIPs. The SIP shop drawing explains the fabrication and/or installation of the SIPs to the SIP manufacturer's production crew and the contractor installation crews.

SIPA: Structural Insulated Panel Association (www.sips.org), a non-profit trade association representing manufacturers, suppliers, dealer/distributors, design professionals and builders committed to providing quality structural insulated panels for all segments of the construction industry.

SIPs: Structural Insulated Panels, a high-performance building component for residential and light commercial construction.

Transverse load: a load applied perpendicular to the span of the member.

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SECTION 8:
SIP Design BP 6: SIP Fabrication/ Manufacturing

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SIP DESIGN-BP 6:

SIP Fabrication/Manufacturing[1]

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 *Designing 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
5. SIP Shop Drawings
6. **SIP Fabrication/Manufacturing**
   - **6.1. Blank SIPs are the least expensive, but limit your speed of installation advantage, create additional onsite waste, and require a higher degree of installation skill as all cutting is performed onsite.**
   - **6.2. Prefabricated SIPs are designed and cut in the factory to increase speed of installation and improved fit and finish on the jobsite.**
   - **6.3. An RTA package includes internal lumber and headers provided and preinstalled in the factory to maximize speed and efficiency onsite.**
7. SIP Installation
8. SIP Roof and Wall Assemblies
9. SIP Electrical
10. SIP Plumbing

[1]This updated title replaces "SIP Fabrication" in the checklist on page 15 of the earlier document *Designing with SIPs: DESIGN CONSIDERATIONS*.

SIP DESIGN-BP 6:

SIP Fabrication/Manufacturing

SIPA manufacturers offer differing levels of SIP fabrication. They include blank SIPs, prefabricated SIPs and ready-to-assemble (RTA) packages.

BLANK SIPs require the most amount of onsite preparation.

PREFABRICATED SIPs require an intermediate amount of jobsite preparation.

RTA SIP packages require the least amount of onsite preparation.

SIPA manufacturers can provide details concerning benefits of each option.[2]

SIP DESIGN-BP 6.1:
Blank SIPs are the least expensive[3], but limit your speed of installation advantage, create additional onsite waste, and require a higher degree of installation skill as all cutting is performed onsite.

The definition of a "blank" SIP will vary by manufacturer but is generally considered the most basic of SIPs. Minimum requirements are met, as referenced in the manufacturer's code report – which defines physical characteristics and materials (OSB facers, structural adhesives and a rigid foam core) – and as described in the manufacturer's quality manual which defines lamination procedures. Each blank SIP will carry a certification stamp on the face of the SIP, confirming the SIP has been laminated to these standards.

A blank SIP is typically laminated as either a 4' x 8' or up to an 8' x 24' with core insulation flush with the two facers. These blank SIPs may be referred to as "stock" sizes as they do not call for cutting down to specific dimensions.

Manufacturers may also add a standard foam recess around the perimeter of the SIP, typically 1½ inches in depth, produced for the purposes of joining the SIP to another component, such as another SIP, a base or top plate. A standard configuration of electrical chases may also be included in the "blank" SIP.

Blank SIPs are the least common type of SIP produced by manufacturers. One of the greatest advantages of building with SIPs is the fact that much of the production can be done offsite, which not only lessens the burden for labor in the field, but also ensures the quality of fabrication which is typically done by specialized equipment and finished by experienced fabricators. Reasons SIPs may be purchased as blanks include:

- The contractor or owner may be working from an incomplete set of drawings, and openings and span distances are not finalized.

[2] See the *SIP Design Best Practices Overview* – *Designing with SIPs: DESIGN CONSIDERATIONS*

[3] in upfront material costs; when balanced by labor, waste and other aspects in the field, total installed cost of blank SIPs could be more expensive than prefabricated or RTA SIP packages.

- Urgency to receive the SIPs and avoid manufacturer lead times and value-added steps taken by the manufacturer once the SIP has moved beyond lamination.

- Supplying to an experienced SIP fabricator who creates SIP shop drawings as discussed in *SIP Design-BP 5: SIP Shop Drawings.*

If the blank SIPs are fabricated onsite, contractors should consider the following:

- Does the contractor have proper tools to cut, bevel and recess SIPs?

- Is there adequate room to lay out up to 8' x 24' SIPs to fabricate?

- Does the contractor have the required accessories, including fasteners, tape and sealant?

- Are the headers being sized properly and span charts being followed adequately, according to structural details as developed by a code report, design professional or manufacturer instructions?

- How will waste be managed?

- Something else to keep in mind: when cutting on site, flakes and fragments of foam will cause what is often referred to as a "snowstorm".

Unless there is a unique circumstance concerning the design, a manufacturer will likely encourage clients to cut and recess SIPs in the factory. Unlike materials such as dimensional lumber, SIPs are precision-fabricated by use of specialized cutting equipment and factory-calibrated recessing equipment. This is why prefabricated SIPs, as opposed to blank panels, reduce both installation issues and time in the field.

IMAGE 6.1
EIGHT-FOOT-WIDE BLANK SIPS

SIP DESIGN-BP 6.2:
Prefabricated SIPs are designed and cut in the factory to increase speed of installation and improved fit and finish on the jobsite.

Prefabricated SIP packages are designed and cut according to the SIP shop drawings[4] in a controlled factory environment, typically utilizing specialized cutting equipment. SIPs can have standard or custom electrical chases and foam recesses fabricated, according to the SIP shop drawings for each project. One of the features of a prefabricated SIP package is that the lumber and the splines are not preinstalled, which allows electricians to access electrical chases at doors and windows, facilitating the installation of multiple gang boxes. This also allows builders to efficiently use lumber and minimize lumber waste onsite by utilizing the material for window and door bucking.

IMAGE 6.2
PREFABRICATED SIPS

[4] See *SIP Design-BP 5: SIP Shop Drawings*

Prefabricated SIPs utilize the factory environment to have the SIPs cut precisely. Each SIP is numbered according to the SIP shop drawings[5] and marked with a quality control stamp. While lumber and splines will still be required to be installed onsite, prefabricated SIPs eliminate onsite fabricating (i.e., cutting and shaping) and complicated layout of panel shapes and sizes. A prefabricated SIP package helps to speed dry-in time of the envelope. Another benefit of prefabricated SIPs is they greatly reduce the amount of waste on the construction site.

A prefabricated SIP package may include:

- lumber material (sill and top plate)
- SIP spline material according to the SIP shop drawings
- sealant and tape for all joints, with application gun
- screws, nails and long SIP screws for connecting SIPs
- structural components such as beam packages for structural support
- weatherization package

SIP DESIGN-BP 6.3:
An RTA package includes internal lumber and headers provided and preinstalled in the factory to maximize speed and efficiency onsite.

RTA (Ready-to-Assemble) SIP packages are ready to install (other than sealants and taping) when they arrive at the jobsite, eliminating the time needed to perform the individual jobsite operations required for blank SIPs or prefabricated SIPs.

RTA packages include internal lumber and headers provided and pre-installed in the factory to maximize speed and efficiency onsite. With a fully customized RTA package, all the rough openings will be factory cut and bucked out, ready to receive doors and windows. Wiring chases and beam pockets are also factory installed. The RTA package may include plate material, house wrap, seam tape, sealant and application gun, SIP screws, SIP shop drawings, and support beam packages as needed.

Not all SIP manufacturers may provide an RTA package. Check with specific manufacturers.

IMAGE 6.3
RTA (READY-TO-ASSEMBLE) SIP PACKAGES

IMAGE 6.4
RTA (READY-TO-ASSEMBLE) SIP PACKAGES

[5] See *SIP Design-BP 5: SIP Shop Drawings*

Glossary of Terms

Blank SIPs: require the most amount of onsite preparation. A blank SIP is the most basic SIP with typically no cutting or fabrication, thus limiting the possible offsite construction installation speed advantage, creating additional jobsite waste, and requiring a higher degree of installation skill as all cutting is performed onsite.

Dimensional lumber: lumber that is cut to pre-defined, standard sizes (2x, 3x, 4x). Note that the NDS (National Design Specification) defines 1x sizes as boards.

OSB: oriented strand board, a wood structural panel.

Prefabricated SIPs: require an intermediate amount of jobsite preparation. Prefabricated SIPs are designed and cut in the factory to increase site installation speed, improving fit and finish.

RTA SIP packages: require the least amount of onsite preparation. RTA (Ready-to-Assemble) SIP packages include factory preinstalled internal lumber and headers.

SIP fabrication: the process of cutting/shaping to specific dimensions as specified on the SIP shop drawings – all in a controlled environment at the SIP manufacturing facility under expert supervision. The SIPs are numbered for ease of installation. Door/window openings, top plates, splines, embedded lumber, sealants and many other options are included and delivered to the jobsite as a "Prefabricated SIP."

SIP installation: the onsite process of assembling a SIP package by connecting, fastening and sealing according to the SIP shop drawings.

SIP lamination: the process of adhering a foam core (typically expanded polystyrene EPS) to the two external facers (typically OSB) according to stringent quality standards at an audited/code approved manufacturing facility to create a structural insulated panel (SIP).

SIP shop drawings: drawings showing more detail than the architectural/construction documents regarding the SIPs. The SIP shop drawing explains the fabrication and/or installation of the SIPs to the SIP manufacturer's production crew and the contractor installation crews. Refer to *SIP Design Best Practices 5: SIP Shop Drawings*.

SIPA: Structural Insulated Panel Association (www.sips.org), a non-profit trade association representing manufacturers, suppliers, dealer/distributors, design professionals and builders committed to providing quality structural insulated panels for all segments of the construction industry.

SIPs: Structural Insulated Panels, a high-performance building component for residential and light commercial construction.

Top plate: a horizontal member positioned between the SIP facers above the foam. Sits under the cap plate. For illustration, refer to Details 3.1 and 3.2 in *SIP Design Best Practices 3: SIP Structural Capabilities*.

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SECTION 9:
SIP Design BP 7: SIP Installation

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SIP DESIGN-BP 7:

SIP Installation

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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
5. SIP Shop Drawings
6. SIP Fabrication

7. SIP Installation

7.1. Training programs are available to installers, ensuring that an educated installer understands the importance of proper installing and sealing of the SIP package. Programs include:

7.1.1. SIPA online training course

7.1.2. SIPA Registered Master Builder & Designer programs

7.1.3. SIPschool hands-on field training

7.1.4. Carpenters International Training Fund (CITF) for SIPs

7.1.5. SIP manufacturer in-house training programs

7.2. Home energy raters verify building air leakage performance with blower door tests and can be found through the RESNET website at www.resnet.us.

8. SIP Roof and Wall Assemblies
9. SIP Electrical
10. SIP Plumbing

SIP DESIGN-BP 7:

SIP Installation

SIP DESIGN-BP 7.1:

Training programs are available to installers, ensuring that an educated installer understands the importance of proper installing and sealing of the SIP package.

SIPA has numerous programs in place to train installers to make sure SIPs are installed according to their architectural plans and the manufacturers' subsequent shop drawings.

7.1.1.

SIPA online training courses

A variety of online training resources for both commercial and residential applications are available for both designers (https://www.sips.org/resources/architect-education) and builders (https://www.sips.org/resources/builder-education). Many of these are officially credentialed and approved for continuing education credits from American Institute of Architects (AIA) and other organizations. The on-demand video sessions can be watched, and separate ten-question tests taken online, after which certificates will be automatically emailed immediately after passing.

7.1.2.

SIPA Registered Master Builder & Designer programs

A guided curriculum of ten courses called ***Building Education with SIPs Training*** or the ***BEST*** program has been developed to orient those new to SIPs. The self-standing educational units each have a narrated video, study guide, and an optional accompanying quiz to test comprehension. An overview is available at: https://www.sips.org/resources/bestprogram

Lesson 1 – Introduction to SIPs

Lesson 2 – Basic SIP Design and Engineering

Lesson 3 – SIP Order Process

Lesson 4 – SIP Building Science

Lesson 5 – SIP Layout Drawings

Lesson 6 – SIP Site Planning and Coordination

Lesson 7 – SIP Layout and Panel Installation

Lesson 8 – Integrating Mechanical Systems with SIPs

Lesson 9 – SIP Finish Materials and Detailing

Lesson 10 – Common Objections for SIP Designs

Once completing the set of ten courses, individuals interested can receive a $50 discount for first-year membership to join SIPA as a builder or design professional member. SIPA members are eligible to enter a two-step program. The first step is to become a *Registered SIP Builder* or *Registered SIP Designer*. Individuals desiring to take the second step toward the prestigious *Master SIP Builder* or *Master SIP Designer* credential must then fulfill the further requirements illustrating mastery of SIPs by:

Master SIP Builder Program Requirements

- Completing at least ten (10) SIP structures or having worked with SIPs for a minimum of five (5) years and
- Passing the Registered SIP Builder/ Designer test of 100 questions with a score of 80% or better and
- Submitting a blower door test result conducted by a RESNET-certified energy rater from a recently completed SIP project with a result not to exceed 2.0 ACH50 and
- Completing the SIPA Master Builder Checklist on the blower door tested project

Master SIP Designer Program Requirements

- Completing at least ten (10) SIP structures or having worked with SIPs for a minimum of five (5) years and
- Passing the Registered SIP Builder/ Designer test of 100 questions with a score of 80% or better

Master SIP Builders and Master SIP Designers are distinguished by unique profiles on the SIPA website (https://www.sips.org/sip-experts/master-builder-profiles) and also receive special designations and filtering included as part of the SIPA member directory. Special promotional mentions in SIPA newsletters and social media channels are additional benefits of achieving the *Master SIP* designation. Members holding this highest SIP designation enjoy elevated business traffic.

IMAGE 7.1
SIPA BADGES

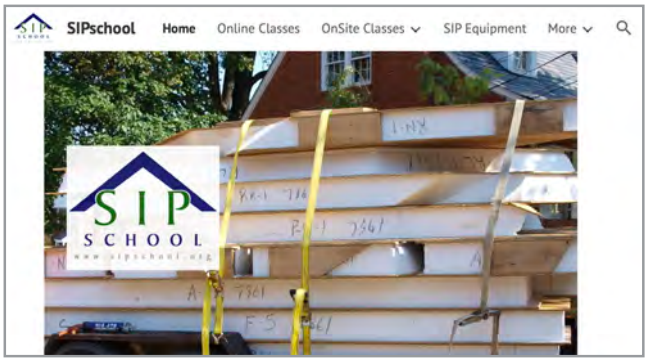
7.1.3.

SIPschool hands-on field training

SIPschool (www.sipschool.org) was established in 2006 by industry veteran Al Cobb to provide training and consulting in SIP manufacturing, design and construction for a fee. For those considering building with and/or installing SIPs in a hands-on or supervisory role, in-person ***SIPschool*** training can give you the knowledge to help ensure your successful SIP installation. Instructors address the details used within the SIP industry, across all SIP manufacturers. Regardless of which structural insulated panel system you're using, the building science to SIP installation is universal. Find out more at: https://www.sipschool.org/OnSiteClasses

IMAGE 7.2

SIPSCHOOL HOME PAGE



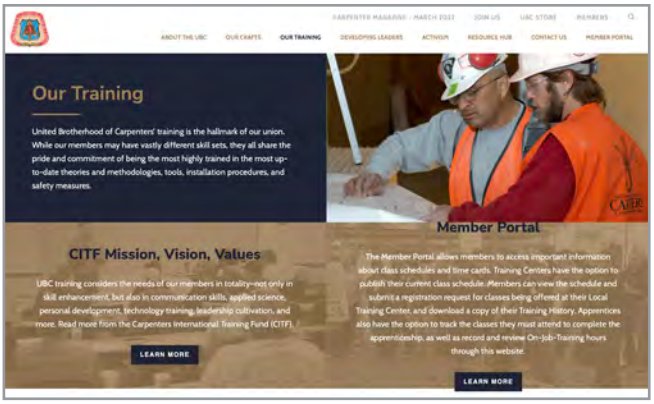
7.1.4.

Carpenters International Training Fund (CITF) for SIPs

SIPA collaborated with the United Brotherhood of Carpenters (UBC) trade union, which focuses primarily on commercial construction, in the creation of a detailed 'train the trainer' program curriculum. Contact the national training headquarters in Las Vegas, Nevada or the local union to conduct this training. More information can be found at: https://www.carpenters.org/citf-training/.

IMAGE 7.3

CITF WEBSITE



7.1.5.

SIP manufacturer in-house training programs

SIP manufacturers offer a variety of training programs to help designers, builders and owners become familiar with the design, use and installation of SIPs. These training programs may consist of the following, to name a few:

- On-site training
- Training at the manufacturer's facility
- AIA accredited training sessions
- Live webinars
- Recorded training sessions
- YouTube videos
- Construction/installation guides

Check with the various SIP manufacturers you are working with for the training programs that are offered. Visit online at https://www.sips.org/resources/architect-education for help in scheduling face-to-face educational presentations.

SIP DESIGN-BP 7.2:

Home energy raters verify building air leakage performance with blower door tests and can be found through the RESNET website at www.resnet.us.

Blower door air leakage tests are conducted by creating a pressure difference of 50 pascals between the inside and outside of the structure being tested. The leakage rate is often referred to as air changes per hour at 50 pascals of pressure or ACH50 which represents a 20-mph wind on the exterior of a structure. Properly installed SIP structures regularly achieve leakage rates below 2.0 air changes per hour at a pressure of 50 pascals (ACH50), to as low as 0.3 ACH50 which is below the Passive House standard of 0.6 ACH50.

IMAGE 7.4

BLOWER DOOR TEST ASSEMBLY

IMAGE 7.5

BLOWER DOOR TEST DATA ACQUISITION

The blower door tests demonstrate that SIPs outperform most envelope systems due to their low air leakage, stable R-values, and low framing factor (about 3 percent[1]) by eliminating embedded dimensional lumber, thus reducing thermal bridging. When lowering the air leakage rate, less outside air needs to be conditioned. Refer to the information on designing HVAC Systems with SIPs as part of the SIP Best Practices series at SIPs.org (https://www.sips.org/resources/design), ***SIP DESIGN-BP 2.4: HVAC Systems with SIPs***, for typical SIP air leakage rates and associated information.

IMAGE 7.6

SIP DESIGN-BP 2: HVAC SYSTEMS WITH SIPS

[1]See *SIP DESIGN BP-1: High-Performance SIP Building Envelope*, Appendix 1.2 on page 21, showing framing factor (weighting %) for a 4' x 8' wall panel.

Glossary of Terms

ACH50: the abbreviation for air changes per hour at 50 pascals (Pa) pressure differential and one of the most important metrics used to determine the energy efficiency of a house. It is the measurement of the rate of air leakage: the number of times the air volume in a building exchanges per hour at 50 Pa of pressure from a blower door test. It is considered equal to wind of approximately 25 miles per hour blowing on the outside of a building.

Dimensional lumber: lumber that is cut to pre-defined, standard sizes (e.g., 1-inch x 4-inch, 2-inch x 4-inch, etc.).

Framing factor: the ratio of the area of all wood structural members in contact with both the interior and exterior facers of the panels (e.g., studs and top and bottom plates) to the total surface area of the panel being considered.

HERS: Home Energy Rating System. The HERS index measures energy consumption from heating, cooling, water heating, lights, and some appliances. The lower the index, the less energy a building is consuming. A HERS rating of zero signifies a net-zero energy building.

HVAC: heating, ventilation and air conditioning.

R-value (thermal resistance): the inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady state conditions, per unit area (h*ft2*0F/Btu).

SIPA: Structural Insulated Panel Association (www.sips.org), a non-profit trade association representing manufacturers, suppliers, dealer/distributors, design professionals and builders committed to providing quality structural insulated panels for all segments of the construction industry.

SIPs: Structural Insulated Panels, a high-performance building component for residential and light commercial construction.

SIPschool: SIPschool (www.sipschool.org) was established in 2006 by industry veteran Al Cobb to provide training and consulting in SIP manufacturing, design and construction for a fee.

Thermal bridging: the movement of heat across an object that is more conductive than the materials around it. The conductive material creates a path of least resistance for heat. Thermal bridging can be a major source of energy loss in homes and buildings.

Written and compiled by SIP Industry Professionals:

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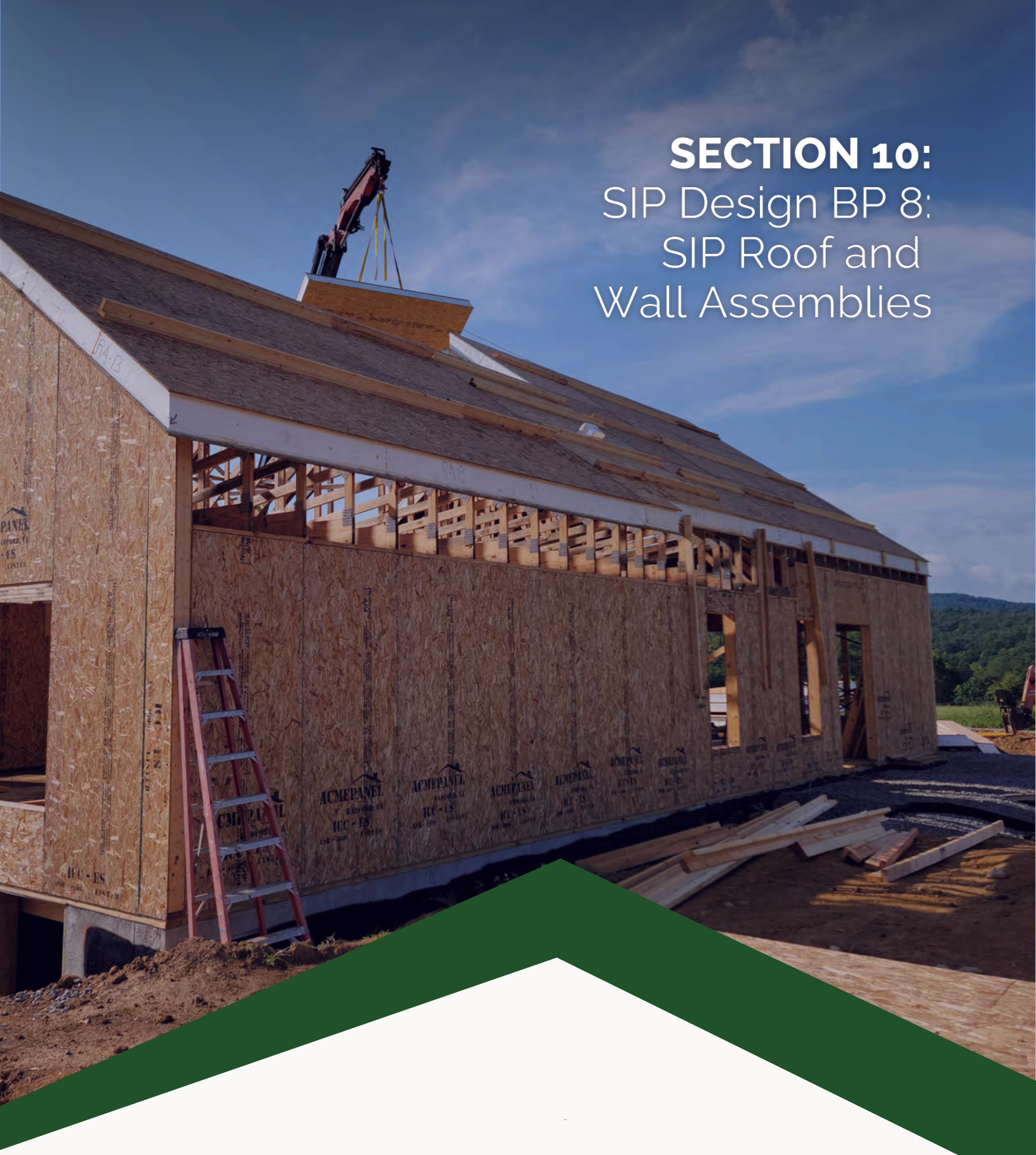

SECTION 10:
SIP Design BP 8: SIP Roof and Wall Assemblies

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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
5. SIP Shop Drawings
6. SIP Fabrication
7. SIP Installation
8. **SIP Roof and Wall Assemblies**
   - **8.1. Design for the appropriate climate zone to maximize durability.**
   - **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.**
   - **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.**
   - **8.4. A back-ventilated cladding may be appropriate for some climate zones and moisture regions.**
   - **8.5. Some claddings may require special fastening patterns for attachment to SIP facings.**
   - **8.6. Use code-approved underlayment and roof covering.**
   - **8.7. Application of fully adhered products to SIP roofs is not recommended. A separation layer is recommended to facilitate future roofing (cladding system) replacement.**
   - **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.**
   - **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

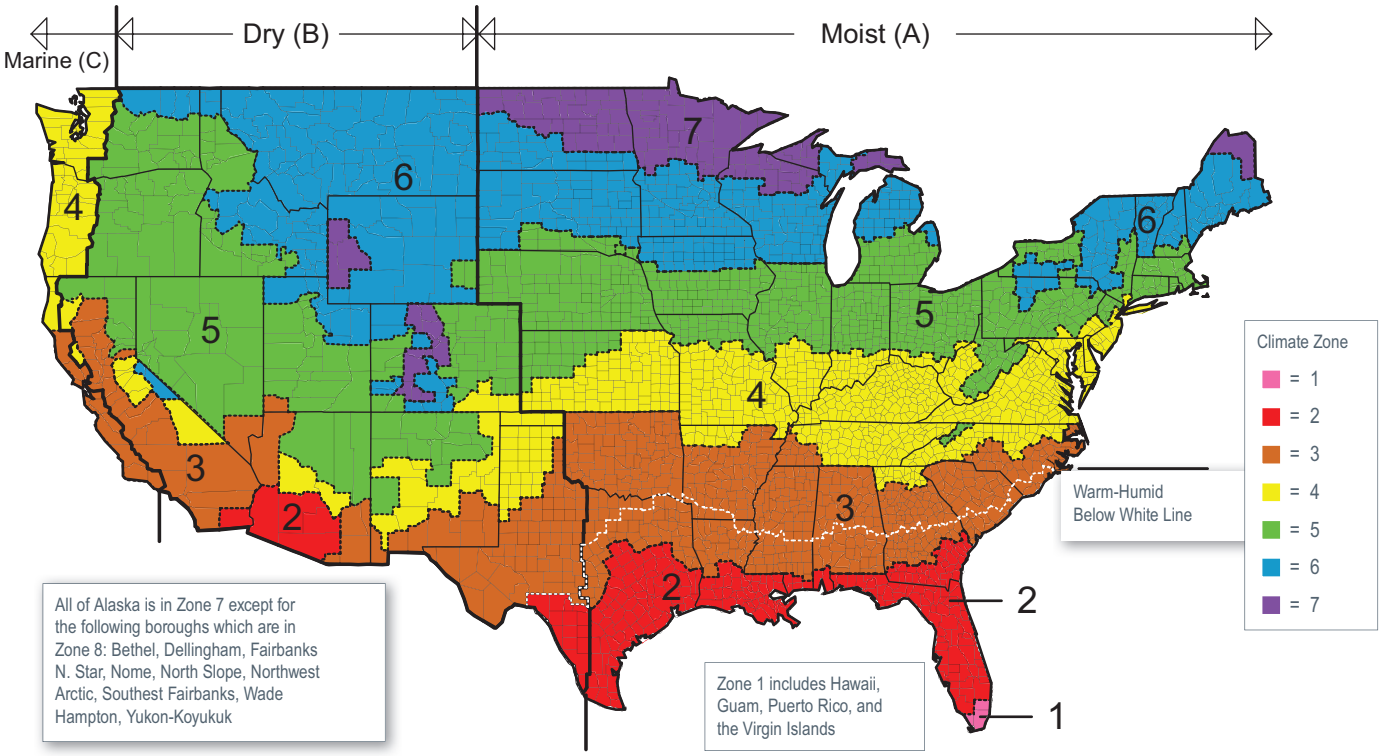
SIP DESIGN-BP 8.1:
Design for the appropriate climate zone to maximize durability.

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



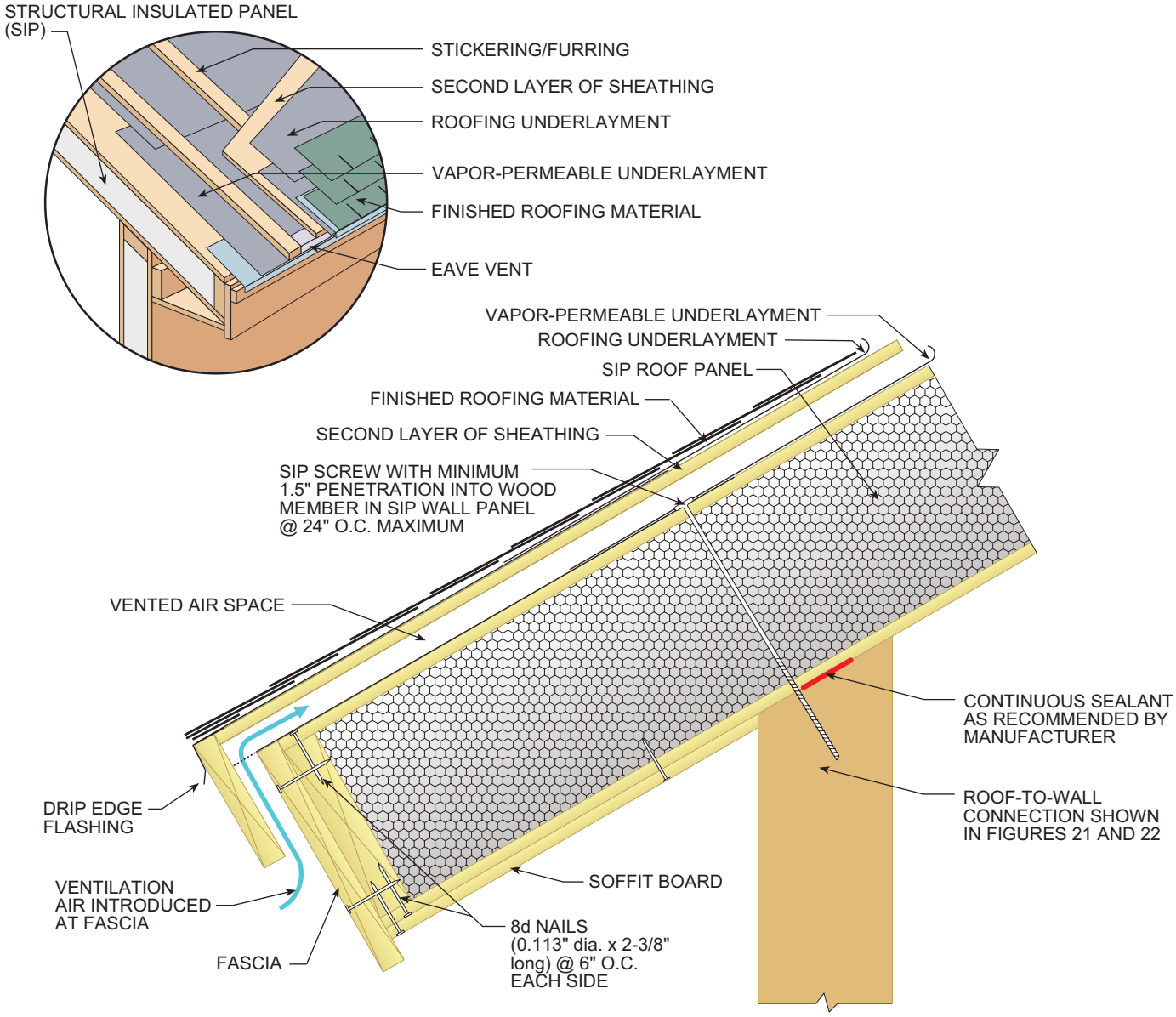
SIP DESIGN-BP 8.2:
Do not use low perm underlayments (i.e, ice and water shield) on a SIP roof with the exception of eaves and valleys.[1]

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*).

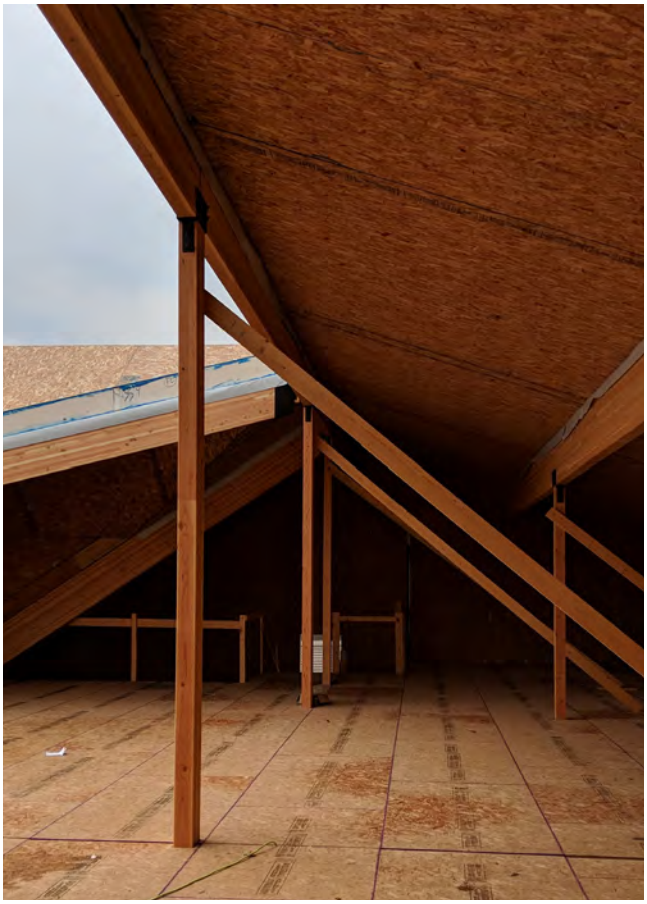
However, as with other wood-based products, long-term exposure of SIPs to moisture can result in structural degradation of the OSB. Therefore, it is imperative that the wall cladding system used with the SIPs – which may include metal siding, wood siding, stucco, masonry or others – provide drainage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

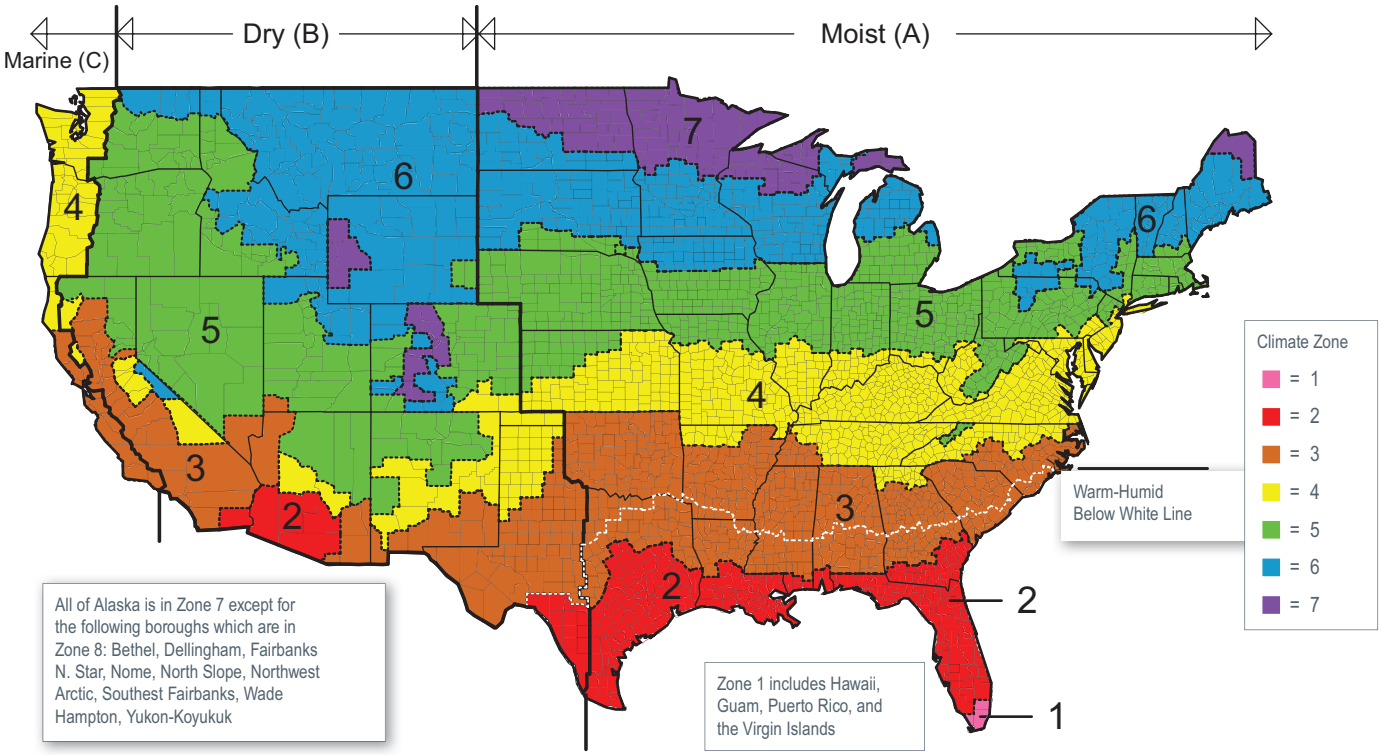
[3] Membrane roofing products such as TPO (thermoplastic polyolefin), EPDM (ethylene propylene diene monomer) and PVC (polyvinyl chloride)

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

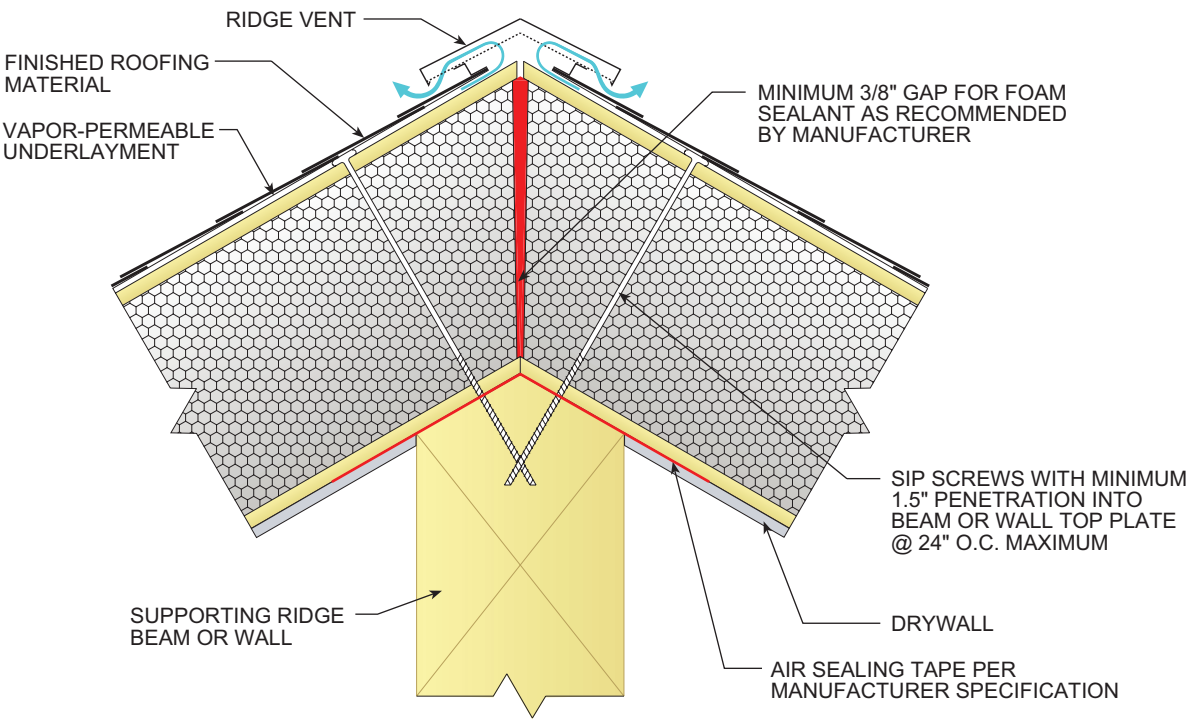
[6] This topic is an addition to those listed in the earlier document ***DESIGN CONSIDERATIONS.***

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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SECTION 11:
SIP Design BP 9: Electrical

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SIP DESIGN-BP 9:

SIP Electrical

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8. SIP Roof and Wall Assemblies
9. **SIP Electrical**
   - **9.1. Vertical and horizontal chases are provided in SIP walls assisting with wiring at outlet and switch heights.**
   - **9.2. Wall and roof chases can be added or removed, prior to SIP manufacture. Shop drawings confirm all chase locations to avoid unnecessary cutting of SIPs in the field. Pre-planning for installation and special chase locations is critical.**
   - **9.3. Electrical chases should be sealed after electrical rough-in inspection to maximize airtightness.**
   - **9.4. An experienced SIP installer is your best insurance that the electrical rough-in will go smoothly.**
   - **9.5. Recessed lights are not recommended for installation in SIP roofs. Use of surface mounted LED lighting is recommended.**
10. SIP Plumbing

SIP DESIGN-BP 9:

SIP Electrical

SIP DESIGN-BP 9.1:
Vertical and horizontal chases are provided in SIP walls assisting with wiring at outlet and switch heights.

SIP manufacturers may provide electrical wiring chases in wall panels. The chases are approximately 1-1/4” in diameter and are located in the foam insulation core of the SIP. Horizontal chases in the wall panels are located at switch and outlet heights, approximately 14” and 48” from the bottom of the panel. Vertical chases are located approximately 4’ on center in the wall panels. Additional chases may be added. Consult the manufacturer that you are working with.

The sill plates, top plates, cap plates and lumber splines need to be drilled with an approximate 1-1/2” diameter drill bit when the panels are being installed by the installation crew at the vertical or horizontal chase locations. These holes facilitate the installation of the electrical wires during the electrical wiring process.

IMAGE 9.1
SIPS WITH ELECTRICAL WIRING CHASES

IMAGE 9.2
FLOOR SILL PLATE CHASE CUT OUT TO PASS FROM SIP WALL TO BELOW FLOOR.

IMAGE 9.3
INSTALLED LIGHT SWITCHES AND OUTLET BOXES WITH OPEN ACCESS PLUGS NEAR DOOR.

IMAGE 9.4

VARIOUS ELECTRICAL BOX INSTALLATIONS IN SIP WALLS

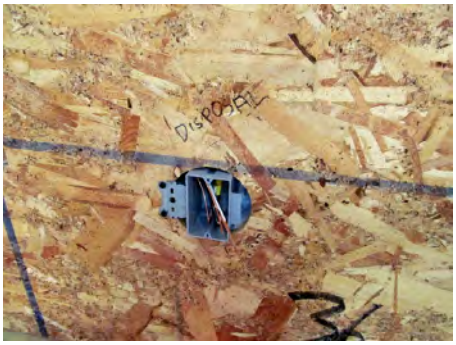


IMAGE 9.5

CEILING BOX INSTALLATION IN SIP ROOF

Note: not shown are the four screw fasteners required to support the weight of a ceiling fan.

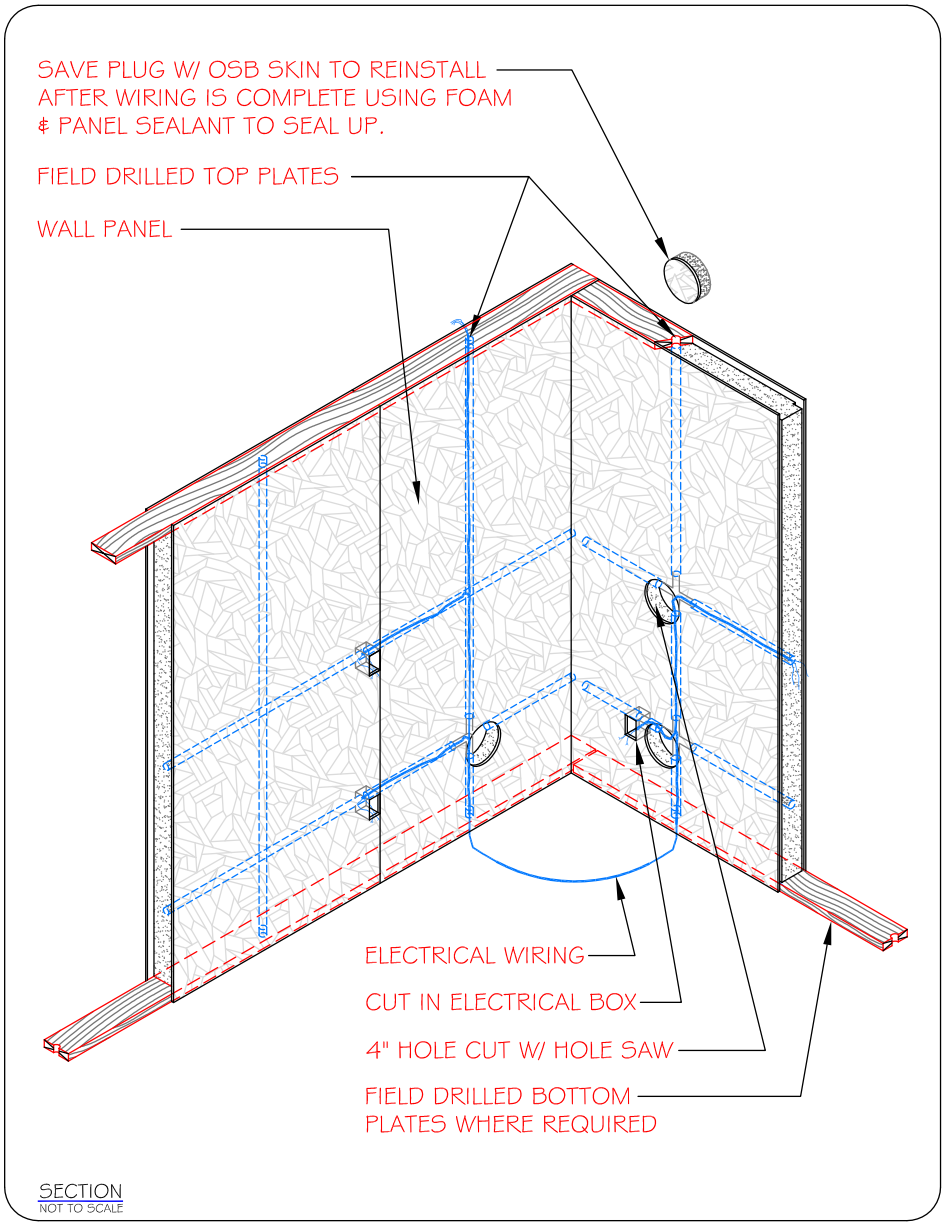
IMAGE 9.6

WHEN DESIGNING THE MECHANICAL ROOM, PLAN FOR FRAMING OUT THE WALL TO ACCOMMODATE THE ELECTRICAL BOX AND ALL WIRING.

SIP DESIGN-BP 9.2:

Wall and roof chases can be added or removed, prior to SIP manufacture. Shop drawings confirm all chase locations to avoid unnecessary cutting of SIPs in the field. Pre-planning for installation and special chase locations is critical.

IMAGE 9.7



Electrical chases are cut prior to adhering facers (typically OSB) to the SIP's core. Therefore, it is important that proper chase locations be confirmed prior to project entering production.

Aside from "standard" chases, referenced in 9.1, above, it is possible to add additional chases. Consideration must be given to the number and location of chases. It is important to remember that a SIP functions as a composite, with each material acting together to create a structural component far greater than any of the materials tested independently. Should electrical chases need to be added at a later date, consult the manufacturer for guidance.

Architectural electrical plans are intended to be interpreted by electricians who are familiar with electrical code requirements, circuit runs, etc. SIP manufacturers look to electrical contractors to provide the specific chase locations that coincide with their installation plan. In many cases, two separate electricians may come up with completely different wire run approaches for the exact same architectural electrical plan. Typically, the default factory electrical chases are sufficient to provide adequate access for electrical runs; however, it would be best to review the SIP shop drawings[1] with your electrician and let your SIP manufacturer know if you would like to add any additional electrical chases within the SIPs.

[2] See *SIP Design-BP 5: SIP Shop Drawings*

SIP DESIGN-BP 9.3:
Electrical chases should be sealed after electrical rough-in inspection to maximize airtightness.

All penetrations made in the SIP facers need to be foamed to minimize air flow through the chases. This is important to do after the electrical rough-in and inspection is complete around all electrical box locations.

The process can be done simply by using a minimal expanding foam similar to what is used around windows and doors. Placing a small amount behind the box, where it intersects with the horizonal or vertical electrical chases in the foam insulation core, will minimize air movement.

It is important to use this same process to seal off holes that were drilled through sill (if accessible) and top plate locations in SIP walls, and in SIP roof overhang locations, whether they were used or not.

SIP DESIGN-BP 9.4:
An experienced SIP installer is your best insurance that the electrical rough-in will go smoothly.

The SIP installer should drill approximately 1-1/2" diameter holes in the top plate, cap plate of the walls, as well as the sill plate in multilevel construction for the vertical chases, and in the splines connecting the panels for horizontal chases.

If these holes are not drilled at these locations in the wall SIPs, the electrical rough-in will be very difficult. An experienced SIP installer helps ensure this necessary step.

In roof and wall SIPs, climate zone considerations will dictate chase locations regarding moisture concerns. Refer to the manufacturer's installation instructions regarding electrical rough-in for walls and roofs.

SIP DESIGN-BP 9.5:
Recessed lights are not recommended for installation in SIP roofs. Use of surface mounted LED lighting is recommended.

There are limitations on the type of lighting that can be used in SIP roof or ceiling applications. Recessed or can lights that are intended to be recessed into a finished ceiling are not recommended for application in SIP product.

There are two primary considerations with using recessed lighting in SIP roofs (i.e., the interior SIP facer is the ceiling surface). First, the OSB facers of the SIPs are a key component of the structural integrity of the panel and excessive cutting of the face will lead to a reduction of the structural capacity. Secondly, the heat created by the lighting and the reduction of the insulation in the SIP can lead to hot spots on the roof and possible condensation issues. The heat generated from the recessed light fixture can damage the SIP core.

The lighting choices can be resolved in the design stage. Some of the options include the use of track lighting or surface mounted LED lighting. Furring down below the interior roof SIP facer is an alternative for installing recessed lighting.

IMAGE 9.8
FURRED-DOWN CEILING FOR CAN LIGHTS

IMAGE 9.9
ALTERNATIVE FURRED-DOWN CEILING

IMAGE 9.10
THIN PROFILE LED LIGHT

Glossary of Terms

Cap plate: lumber ripped to the width of the panel that bears on the top of both facers of the SIP below. Not a top plate; it bears on the top plate. For illustration, refer to Details 3.1 and 3.2 in *SIP Design Best Practices 3: SIP Structural Capabilities.*

Capillary break: a material used to separate the OSB facers from the concrete. Consult SIP manufacturer for appropriate recommendations.

Electrical Chase: a channel in a wall to allow electricians to run their cables in.

Electrical Cut-out: an opening in the facer to recess an electrical box.

Sill (or sole) plate: a wood framing component on the bottom of a wall.

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

SIPA: Structural Insulated Panel Association (www.sips.org), a non-profit trade association representing manufacturers, suppliers, dealer/distributors, design professionals and builders committed to providing quality structural insulated panels for all segments of the construction industry.

SIPs: Structural Insulated Panels, a high-performance building component for residential and light commercial construction.

Spline: connection system used to connect two panels together at vertical, in-plane joints. Many different spline systems are available including box/block, surface, I-joist, dimensional lumber and engineered lumber.

Top plate: a horizontal member positioned between the SIP facers above the foam. Sits under the cap plate. For illustration, refer to Details 3.1 and 3.2 in *SIP Design Best Practices 3: SIP Structural Capabilities.*

Written and compiled by SIP Industry Professionals:

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SECTION 12:
SIP Design BP 10: Plumbing

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SIPA
Structural Insulated Panel Association

SIP DESIGN-BP 10:

SIP Plumbing

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
5. SIP Shop Drawings
6. SIP Fabrication
7. SIP Installation
8. SIP Roof and Wall Assemblies
9. SIP Electrical
10. **SIP Plumbing**
    - **10.1. Plumbing is recommended to be placed in interior walls to provide for an optimal exterior building envelope.**
    - **10.2. Minimize roof penetrations and consider consolidating all vents away from south facing roof planes for potential solar array.**

SIP DESIGN-BP 10:

SIP Plumbing

SIP DESIGN-BP 10.1:
Plumbing is recommended to be placed in interior walls to provide for an optimal exterior building envelope.

Plumbing lines should be pre-planned during the SIP design stage of the project. Plumbing supply lines should be kept out of SIP exterior walls. Placement of any piping in the exterior SIP wall reduces the thermal insulation of the EPS core and in cold climate could be at risk of freezing. Plumbing vent lines can be installed in exterior SIP walls. Coordinate with SIP manufacturer.

IMAGE 10.1
PLUMBING VENT PIPE GOING INTO SIP WALL

Facers of the SIP walls should ***never*** be field cut to accommodate plumbing runs unless the manufacturer or design professional is consulted. If piping must be placed along an exterior wall, furring out the interior is recommended (see Images 10.2 and 10.3), or place the piping in a cabinet (e.g., kitchen sink or bathroom, see image 10.4).

IMAGE 10.2

EXTERIOR SIP WALL WITH FURRED OUT STUD WALL ON INSIDE FACER FOR UTILITIES

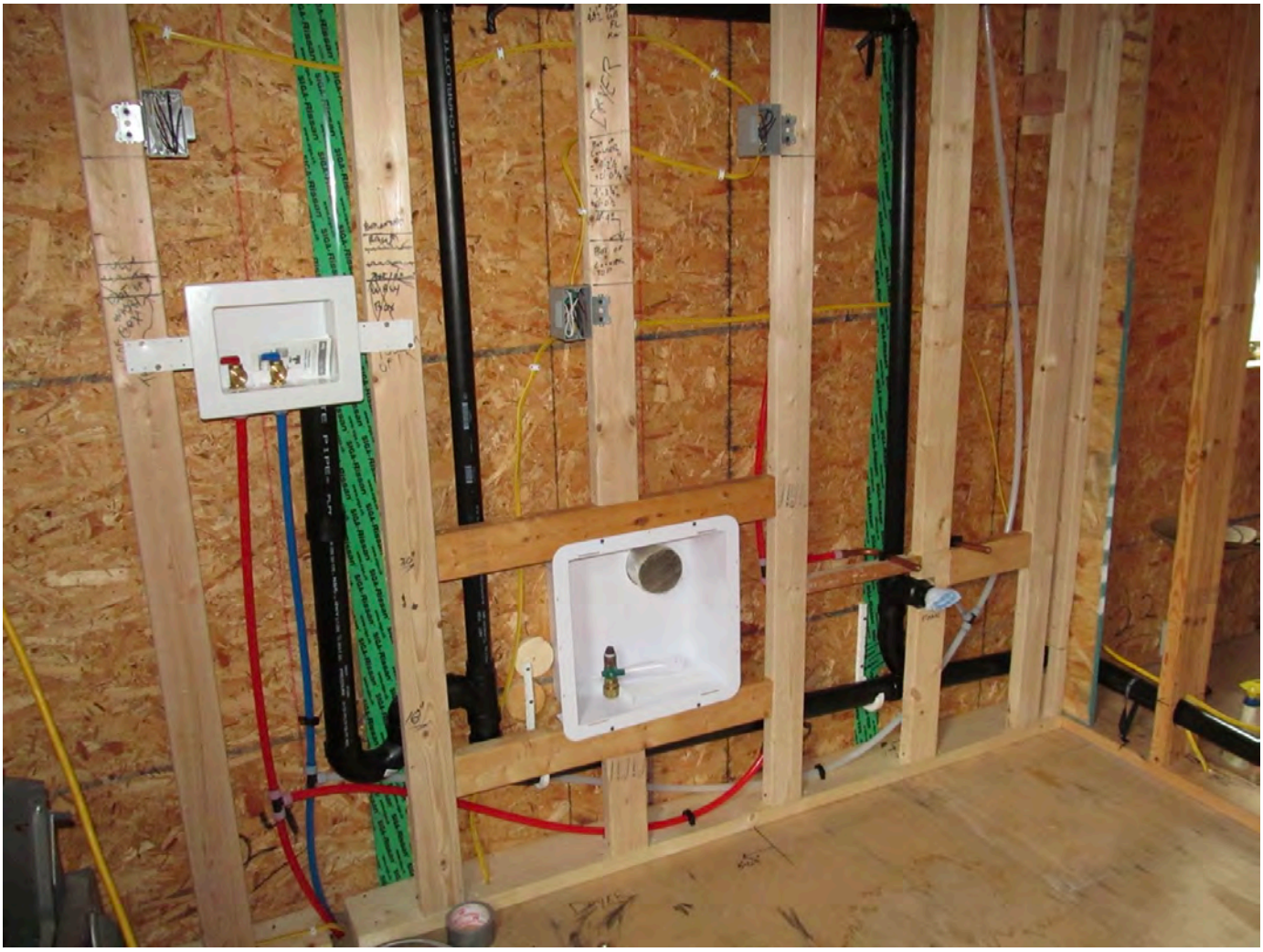


IMAGE 10.3

INTERIOR FURRED OUT STUD WALL FOR UTILITIES WITH DRY WALL

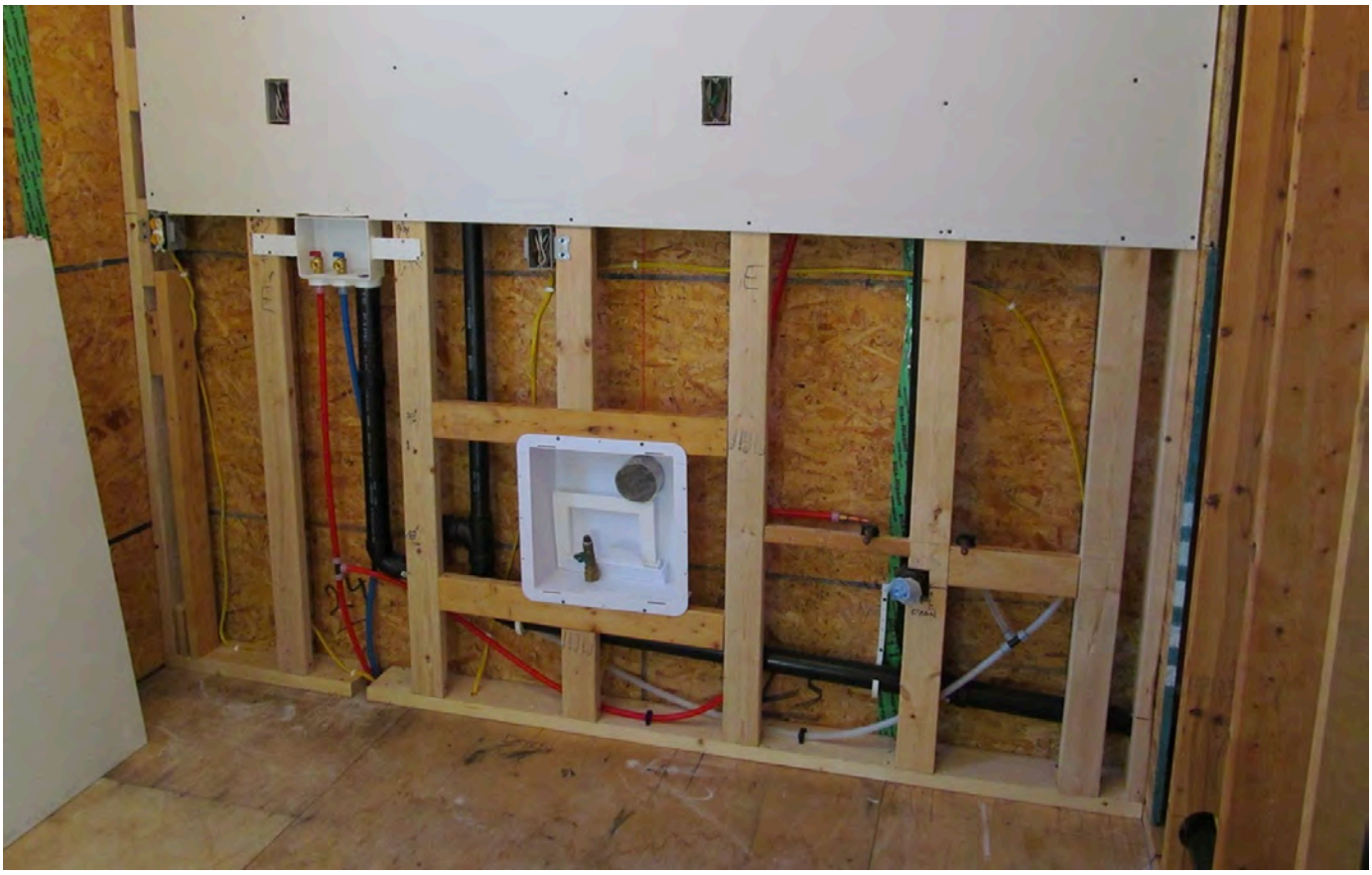


IMAGE 10.4

PLUMBING SUPPLY AND DRAIN PIPING ROUGHED IN FROM FLOOR TO BE HIDDEN IN A CABINET

IMAGE 10.5

WHAT **NEVER** TO DO: CUTTING OF INTERIOR SIP FACER FOR ELECTRICAL OR PLUMBING

IMAGE 10.5.1

EXPANDED VIEW OF IMAGE 10.5

Some jurisdictions allow for a mechanical vent or air admittance valve to be used. The use of an “island or loop” style vent also works well to allow multiple fixtures to be brought to a more central vertical vent pipe location in interior walls, which also minimizes the penetrations through the roof system.

IMAGE 10.6

KITCHEN ISLAND WITH SINK

IMAGE 10.7

ISLAND FIXTURE VENT

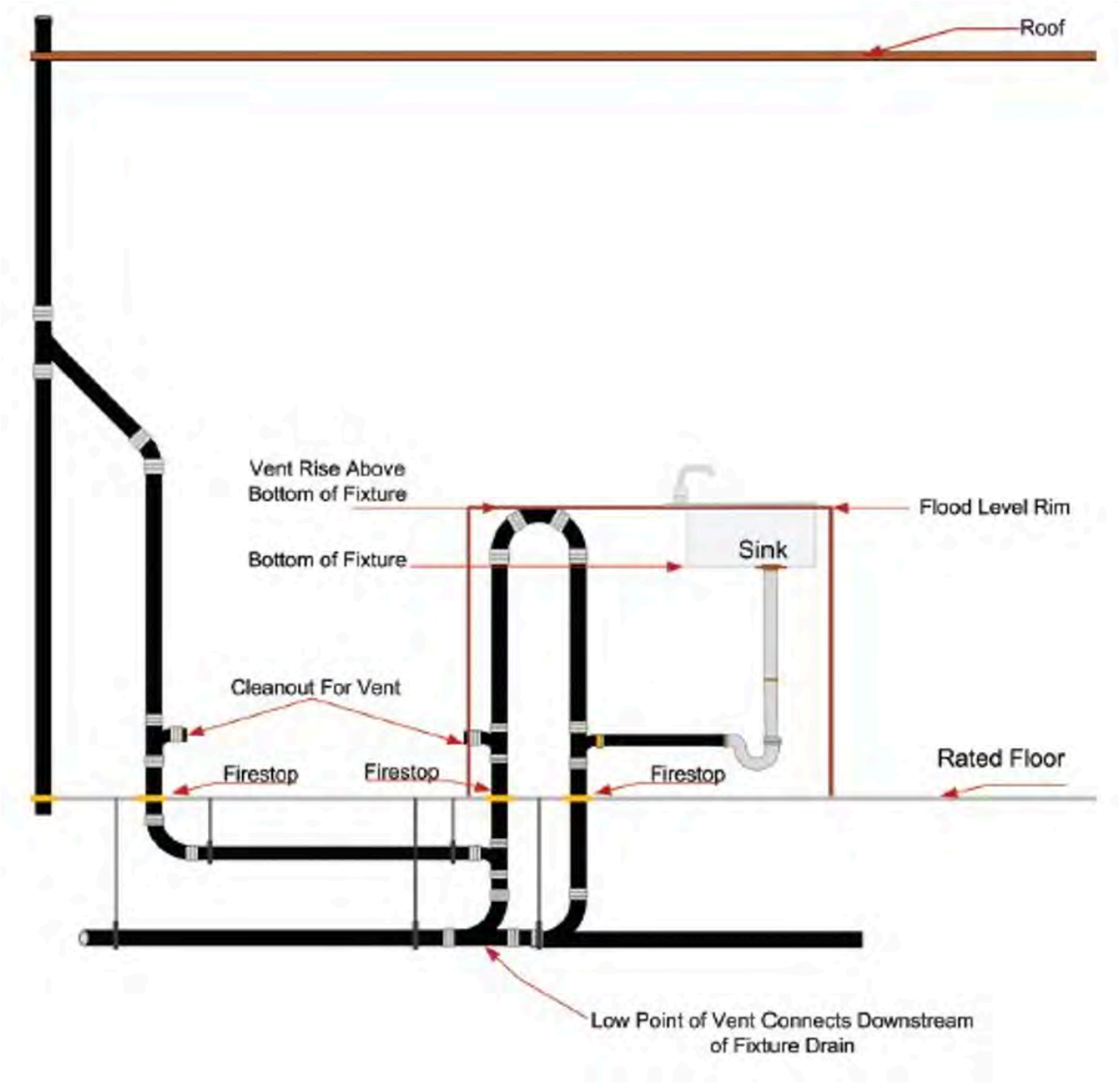


IMAGE 10.8

AIR ADMITTANCE – INDIVIDUAL VENT

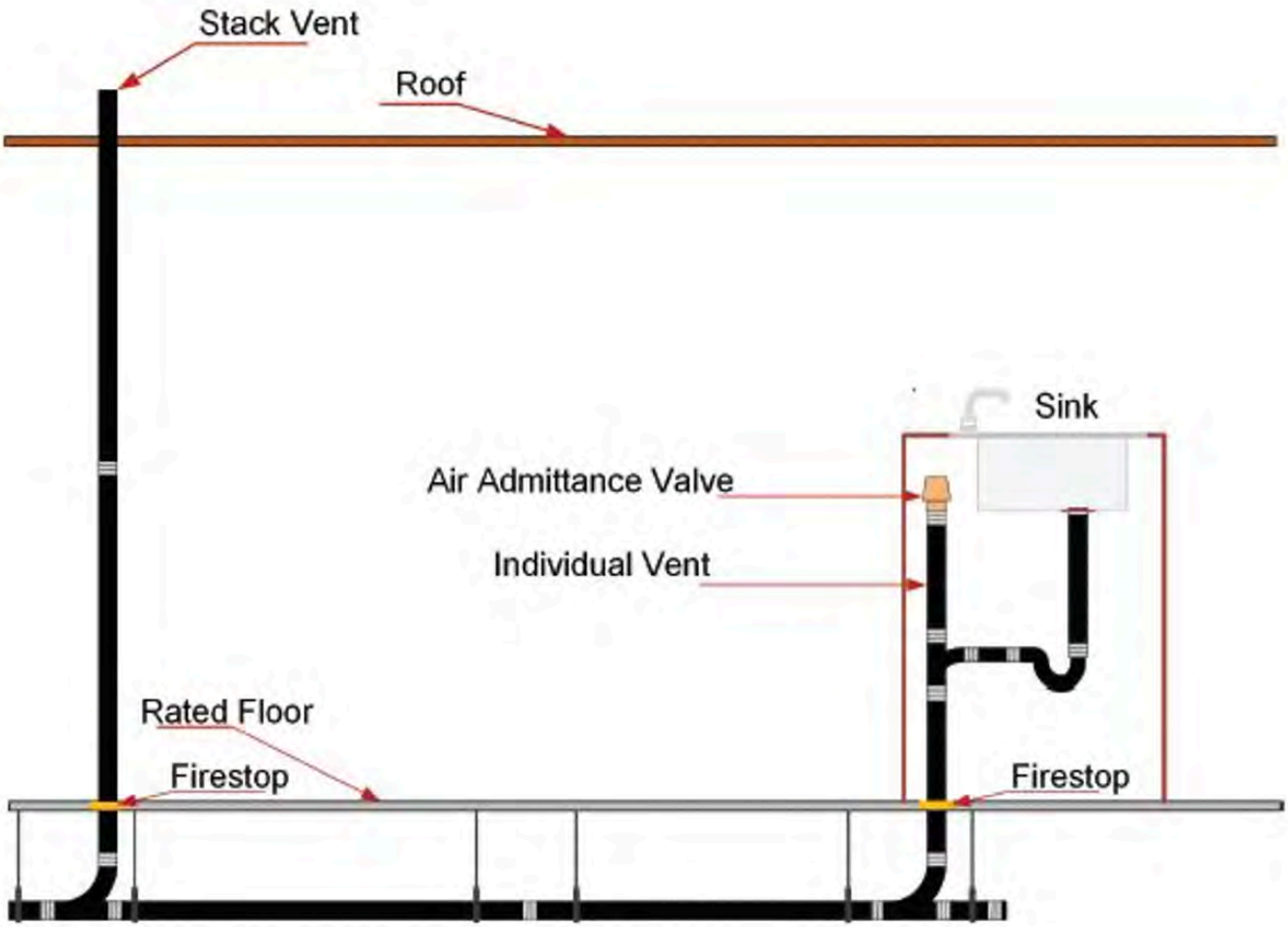
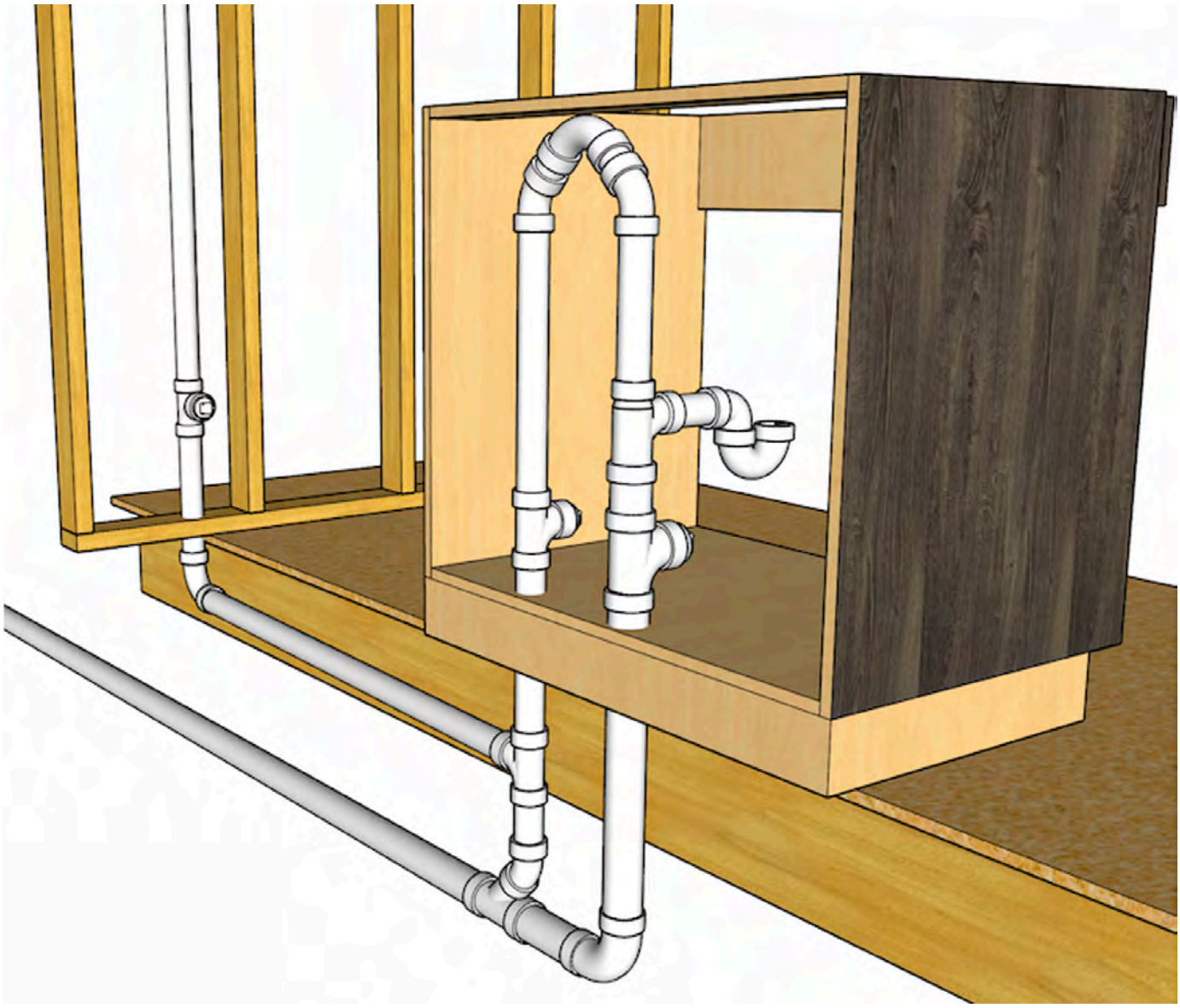


IMAGE 10.9

LOOP STYLE VENT



Note: in this drawing, the exterior wall has been removed for clarity; i.e., this does not depict a kitchen island.

SIP DESIGN-BP 10.2:
Minimize roof penetrations and consider consolidating all vents away from south facing roof planes for potential solar array.

Limiting penetrations through a SIP roof is advised. Penetrations lend themselves to air and moisture leakage. SIPs are considered a high-performance building material based on the airtightness created when monolithic panels are assembled with the intent of reducing joints and air movement.

Even though vent penetrations are site cut, it is recommended to notate these on the shop drawings. This will help to ensure penetration cuts do not coincide with panel connections. Every effort should be made to avoid disturbing a properly sealed SIP joint, which has already been field assembled to limit movement of air and moisture.

Key considerations when penetrations are necessary in a SIP roof:

1) Limit openings to as small a diameter as possible.
2) Always apply a high-expanding foam around the perimeter of a vent pipe, where it exits the SIP. Include this note in plans.
3) With sustainable, zero-energy-ready design in mind, avoid running vent piping through south-facing roof planes. Whether in initial design, or added later, avoiding a south-facing roof plane will make a future solar array easier to install.
4) Combining vents, where feasible, will help to limit penetrations.
5) Avoid running plumbing through a SIP-to-SIP spline joint connection.
6) As is the case with any roof system, consideration should be given to ***avoid*** venting in a path created to remove water from a roof, as is the case in the eave of a dormer (see Image 10.10).

IMAGE 10.10
WHAT NOT TO DO: VENTING BELOW THE EAVE OF A DORMER

IMAGE 10.11
WHAT NOT TO DO: CUTTING INTO A SIP TO RUN PIPING

Glossary of Terms

SIPA: Structural Insulated Panel Association (www.sips.org), a non-profit trade association representing manufacturers, suppliers, dealer/distributors, design professionals and builders committed to providing quality structural insulated panels for all segments of the construction industry.

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