Henri Fennell, CSI/CDT

Henri is an architect and building envelope specialist with over forty years of experience in the construction industry. He was a pioneer in the solar industry, introduced the installation technique for field-applied closed-cell cavity-fill polyurethane foam, developed a pressurized theatrical fog quality assurance technique and protocol, and has designed and constructed a net-zero energy research structure in Antarctica. He has four energy-Related U.S. patents.

HCF foam and panel/SIP experience

1. First spray foam project was in 1970
2. CMU Engineering research project on SIP bond strength - 1972
3. Foam panel/solar manufacturing from 1973 to 1979
4. Foam contracting from 1979 to 2009
   - Developed the method for injecting closed-cell foam on site, ~1,000 projects, installed ~ 3 million pounds of foam
   - Over 100 new installations including numerous SIP remediation projects
5. Foam and building enclosure consulting from 2009 to present
   - Foam panel project planning -- Problem diagnostics & QA inspections
6. Noteworthy foam projects include:
   - The Big Dig, 4 American Ski Grande Hotels in the Northeast, Net-zero energy panelized weather station in Antarctica (SIPs), The Guggenheim Museum
7. Two US patents and two published technical papers related to foam panel products and installation quality assurance

Building Science.com Corporation

SIPs…it's about the joints and more

By: Henri Fennell, CSI/CDT

www.polyurethanefoamconsulting.com

SIPs…it's about the joints and more

Copyright Materials

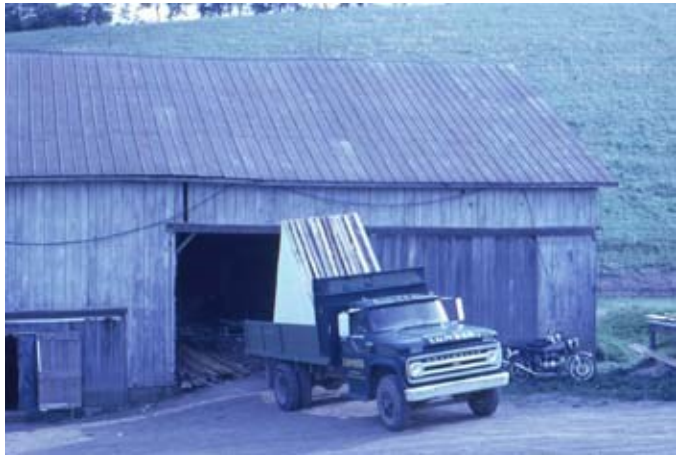
www.polyurethanefoamconsulting.com

1. My first SIPs

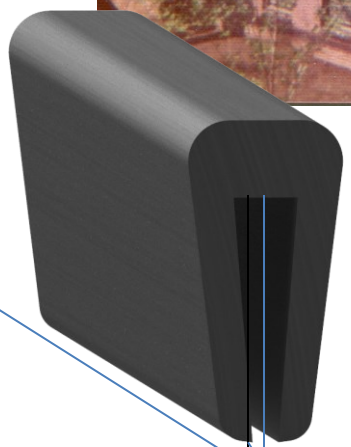
My first SIPs project - 1974

Bucky master solid Zome in progress

Wooden panel press



Steel-skin SIPs



Roll-formed galvanized steel FIP SIPs on new pedestrian bridges in Boston - 1975

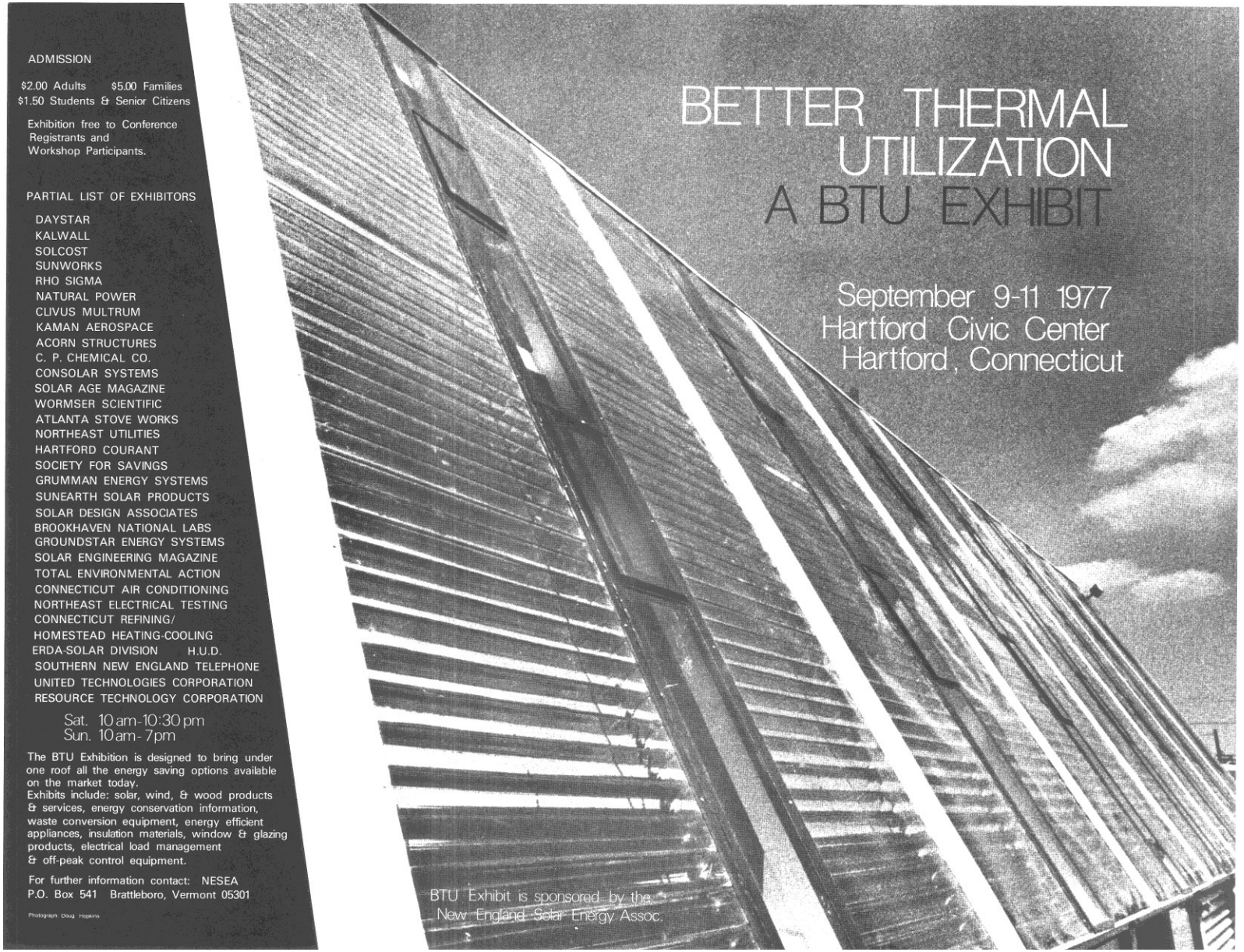
Glued rubber cap seals at the standing-rib panel joints

Steel-skin SIPs

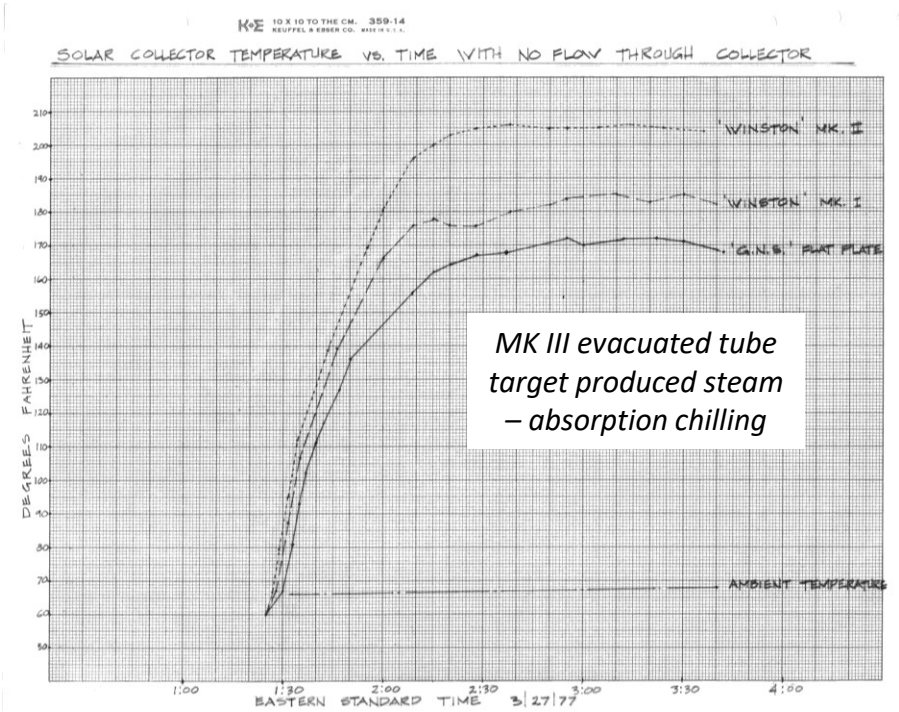
Mattapan Elementary School - 1976

50-year-old left over SIPs

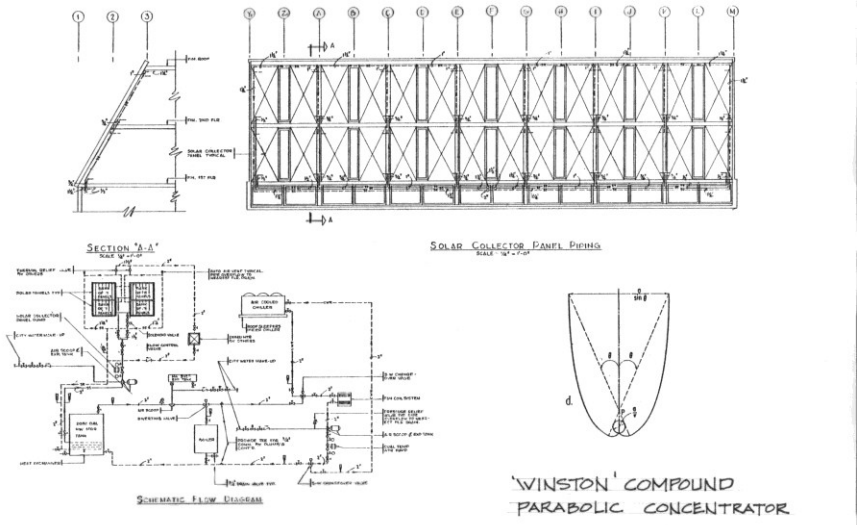
North Thetford, VT – 1975 - today

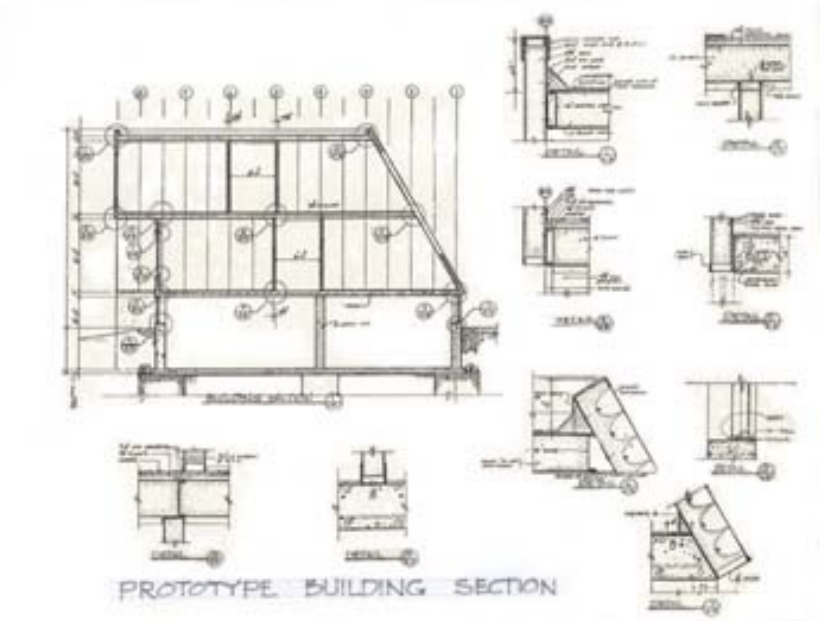


The first NESEA Conference - 1977



U-Conn test data for 3 collector targets

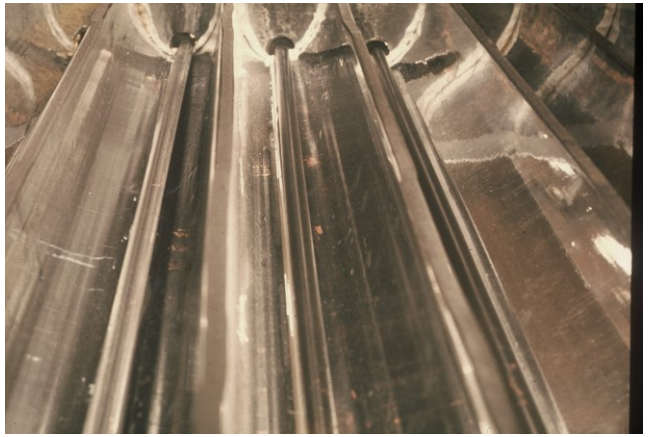




Stucco-embossed galv. steel SIPs

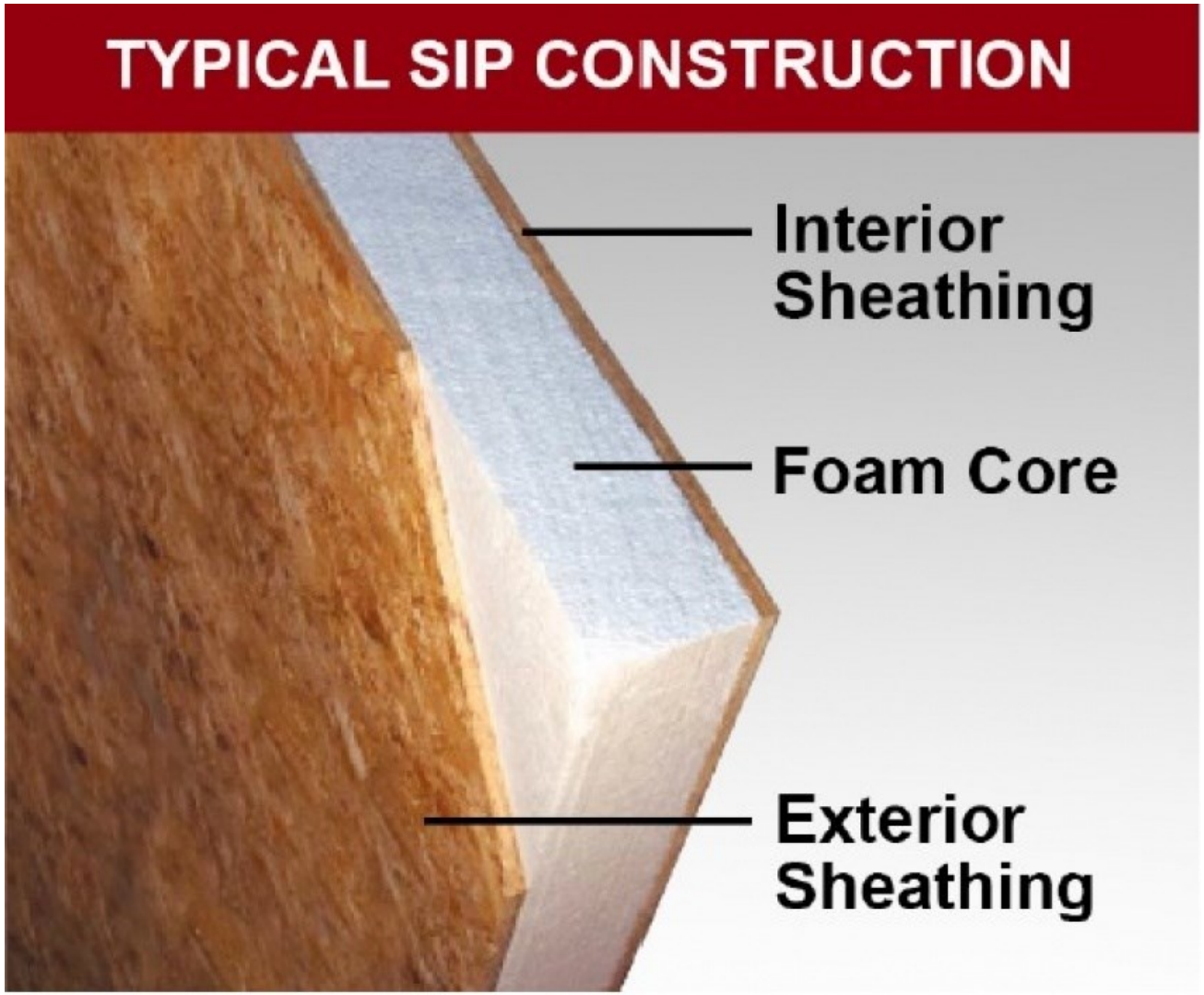
Governor DuKakis at the grand opening - 1976

CPC solar collector panels



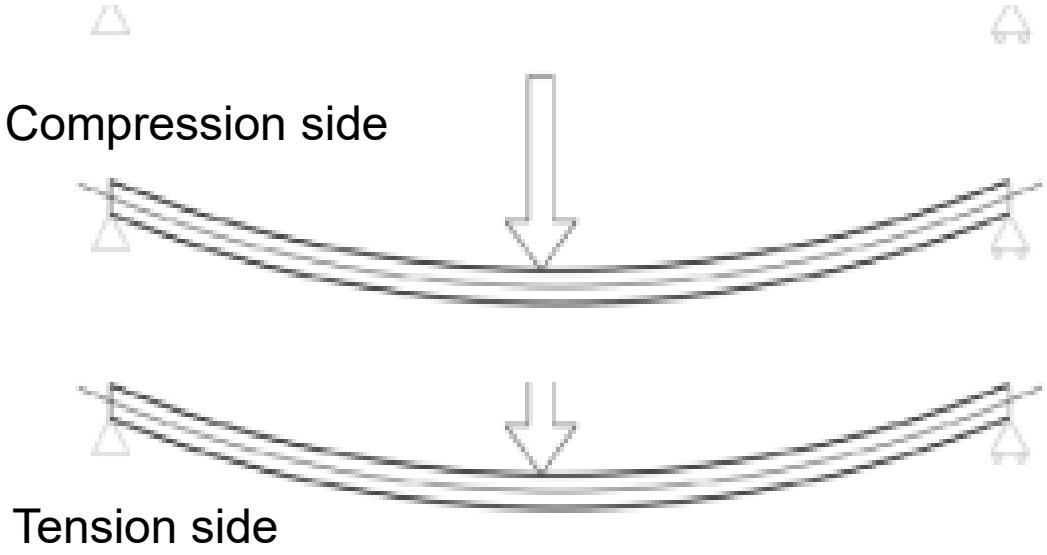
2. What are SIPs?

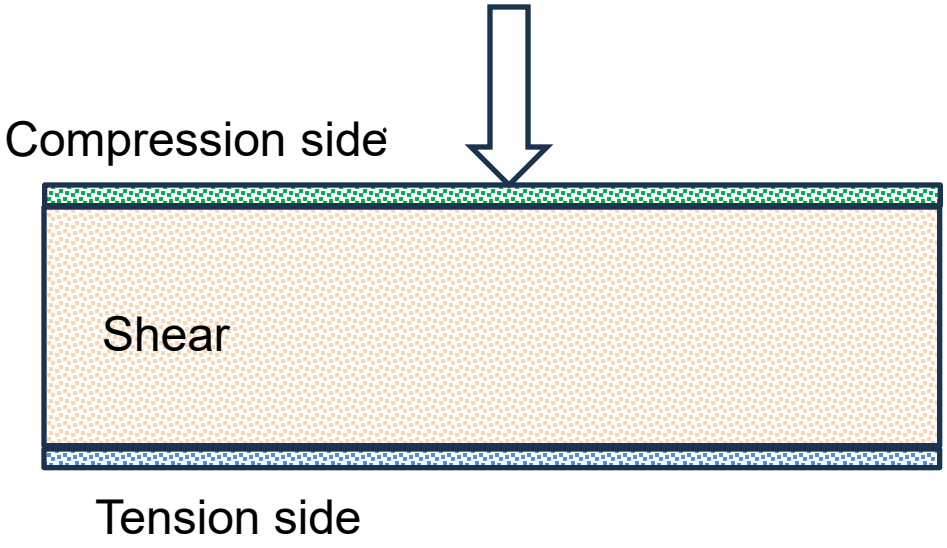
What are SIPs?

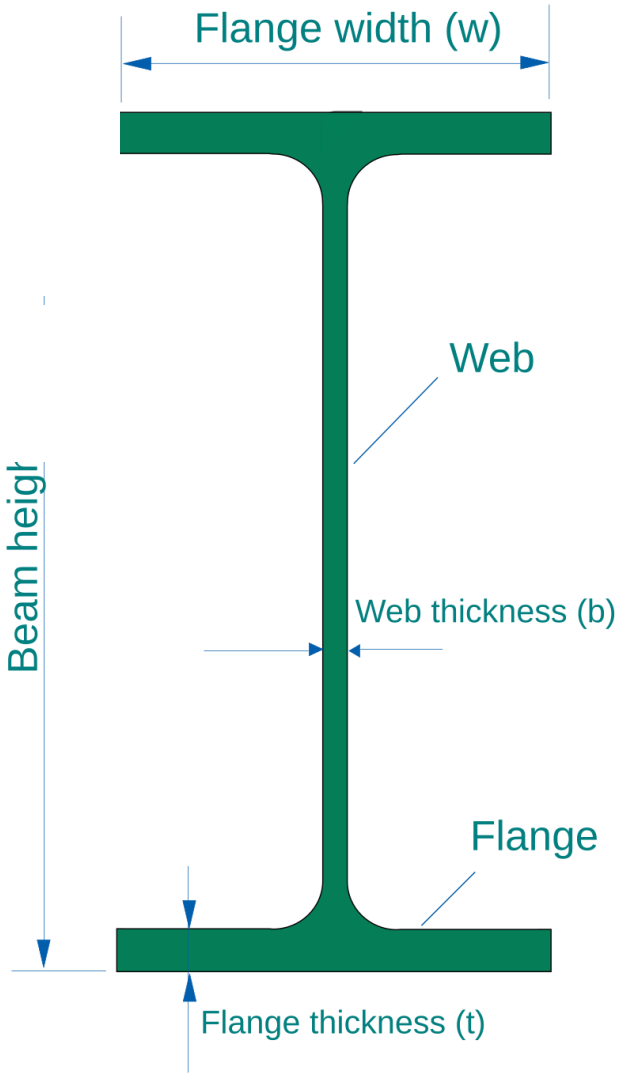


Courtesy SIPA – Structural Insulated Panel Association

What are SIPs?







3. How are they made?

How are they made?

a. Two skins with a foam core
b. SIPs with two skins are structural and can span between supports (drywall is marginal)
c. SIPs can be glued or foamed-in-place (CMU research 1970)
d. The length of the span is determined by the panel thickness and the bond strength of the layers
e. Nailbase products have only one skin and are not structural – they require continuous support but have the same air sealing issues as SIPs

SIPs – a.k.a. sandwich panels

Nailbase products have no tension side; therefore, they are non-structural and must be supported continuously.

Drywall as the tension-side skin does not provide spans as long as OSB or metal skins.

Double-sided EPS SIPs can span from 8 to 24 feet.

Vented Laminated Nailbase Panel

Photograph 8: Vented Foam Panel—The upper panel surface is OSB that acts as a nail base for shingle and other roofing systems.

Courtesy Building Science Corp.

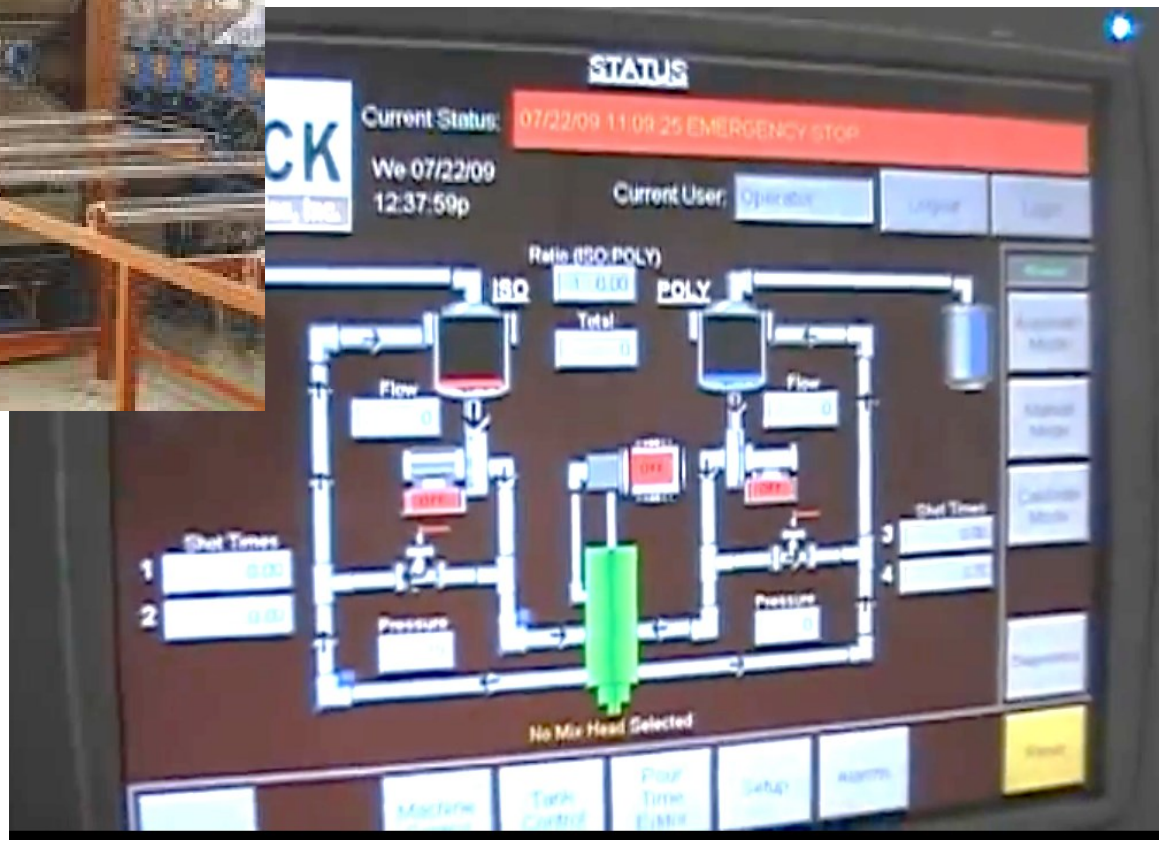
How are they made?

Interior finishes can be attached to custom SIPs or to the frame before the SIPs are installed on top of the finishes.

Lyme, NH, 1987

OEM PUF SIP processing

QA monitors with fault protection capabilities have been in use since 1954



CRIMP lines - Better QA than on-site spray foam or site-built wall assemblies

4. What are they made of?

What are they made of?

- Skins – metal, drywall, manufactured wood, thermoformed plastics like KYDEX, Norel, and Royalite. Other finishes can be attached to the SIPs or to the frame prior to installing the SIPs.
- Cores – Typically made of various types of foam insulation – PUF, EPS, and Polyiso
- Adhesives are required if the SIP is not foamed-in-place.

What are they made of?

1. Structural skins on both sides allow SIP attachment without thermal bridging and provide fastening for cabinets and trim everywhere.
2. Structural skins on both sides provide additional diagonal bracing for the frame.
3. Pre-installed framing at the rough openings carries the weight of windows and doors and allows attachment of the trim.

5. How are they installed?

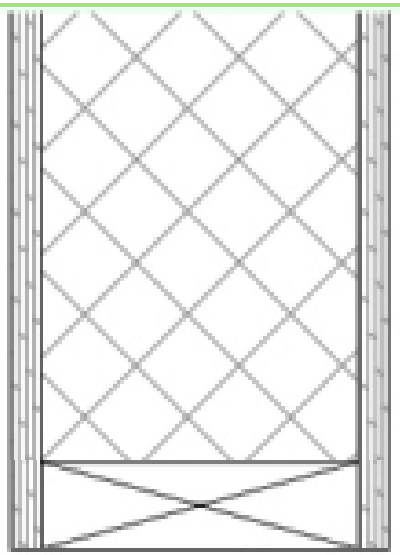
The installation steps

1. Size the SIPs and cut out the rough openings
2. Install the light framing
3. Install termite shields
4. Attach the SIPs to the framing
5. Seal the panel joints
6. QA the joints

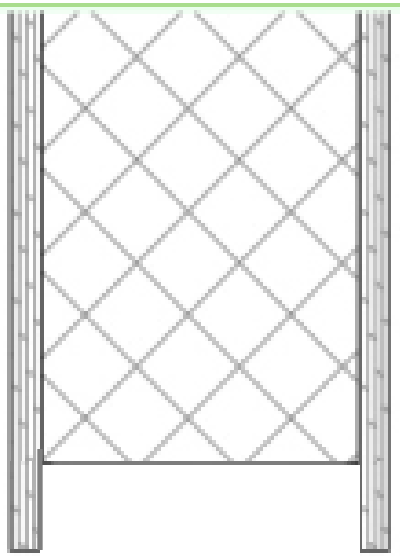
Preparing the SIPs

Cutting SIPs to size

Light framing at rough openings



Routed panel edge with light framing at rough openings



Routed panel edge ready for light framing at rough opening

Light framing at rough openings

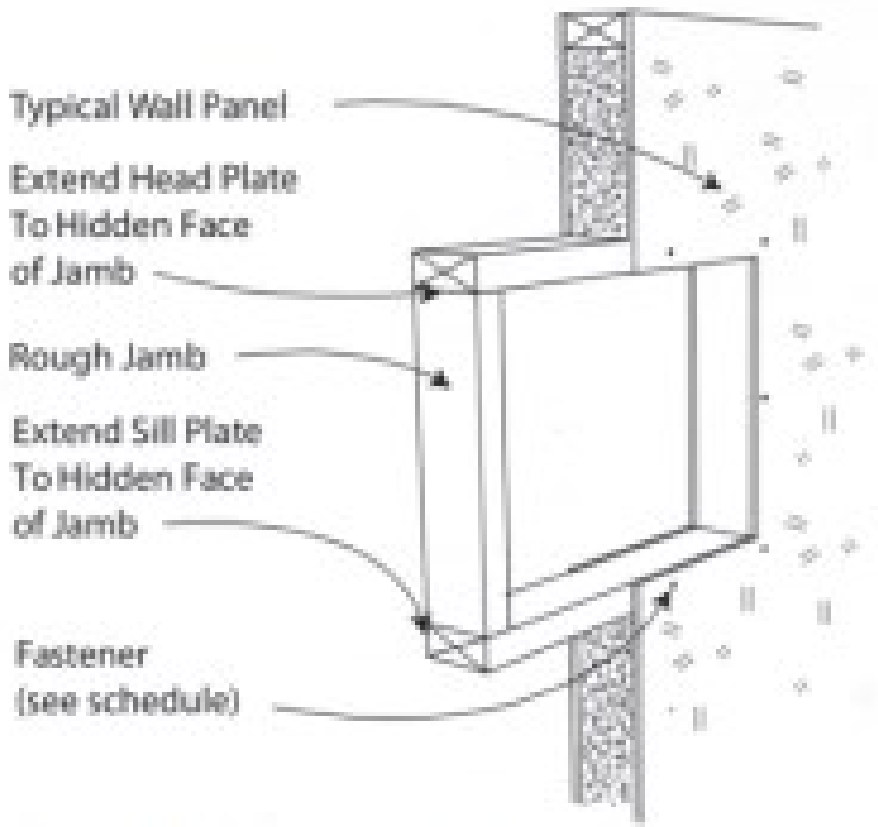


Figure 23. Rough Opening for Window.
The perimeters of window openings are routed out 1 ½" and two-bys installed. The sill and header should overlap side members, as shown.

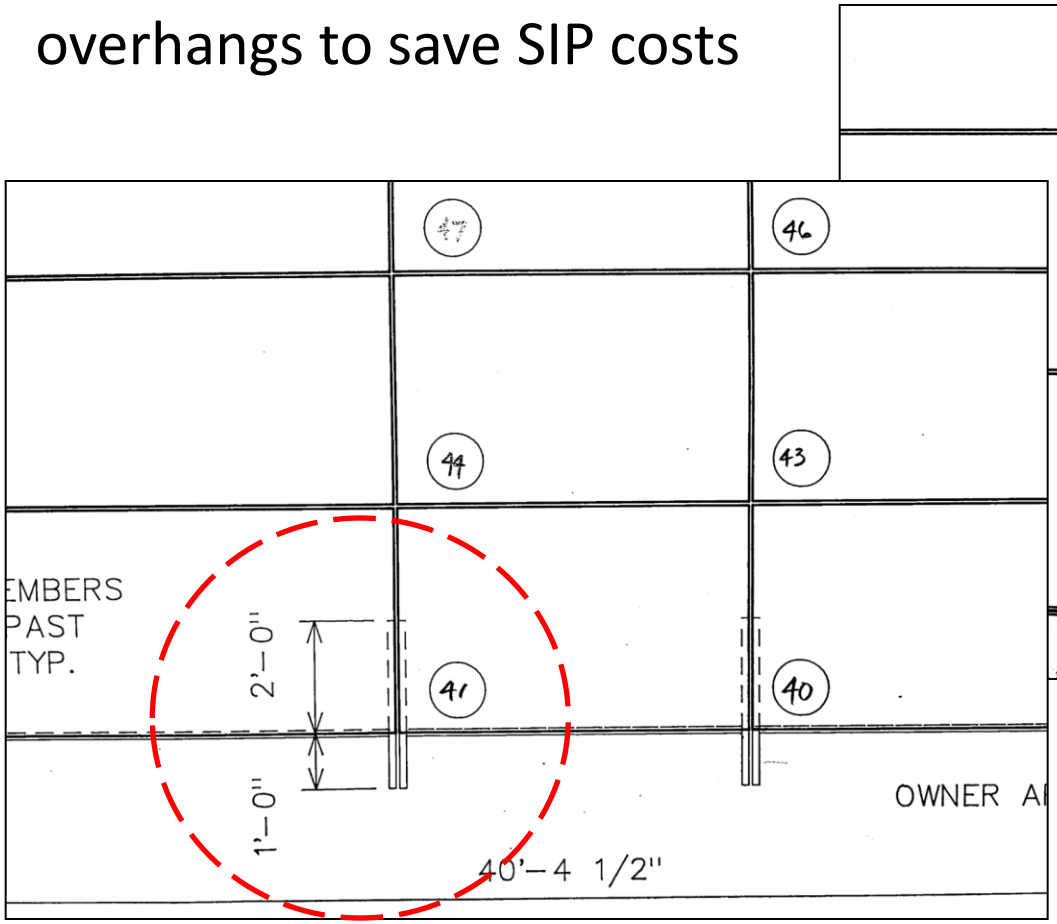
The panel edges must be routed out around an opening to receive light framing. The framing must be sealed into place during or after their installation.

A panel router can be set for a ¾" or a 1 ½" depth.

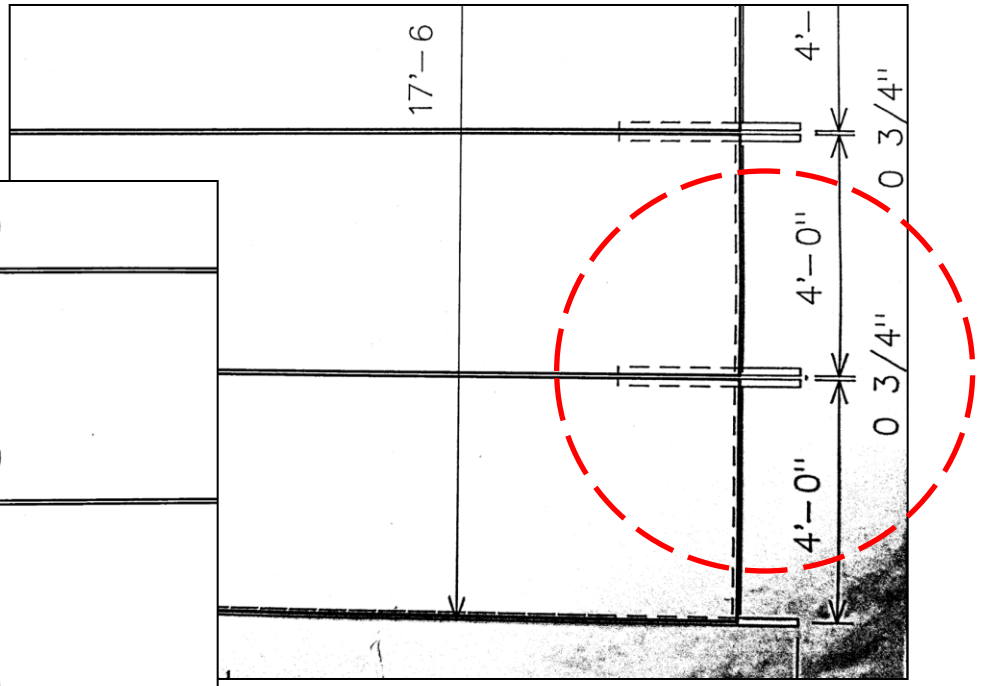
Courtesy Green Mountain Panel

Light framing integrated in SIP roofs

Roof Panel shop drawings showing let-in outriggers for overhangs to save SIP costs



Eave side



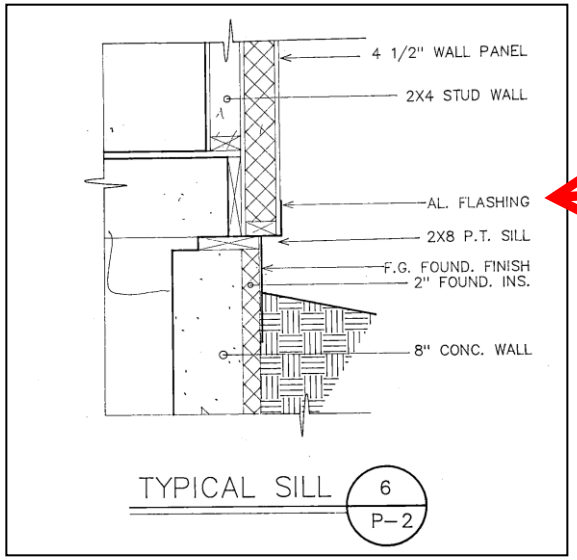
Gable end

F-T shop drawings

It’s all about the details

Winter panels spaced approx. ¾”apart

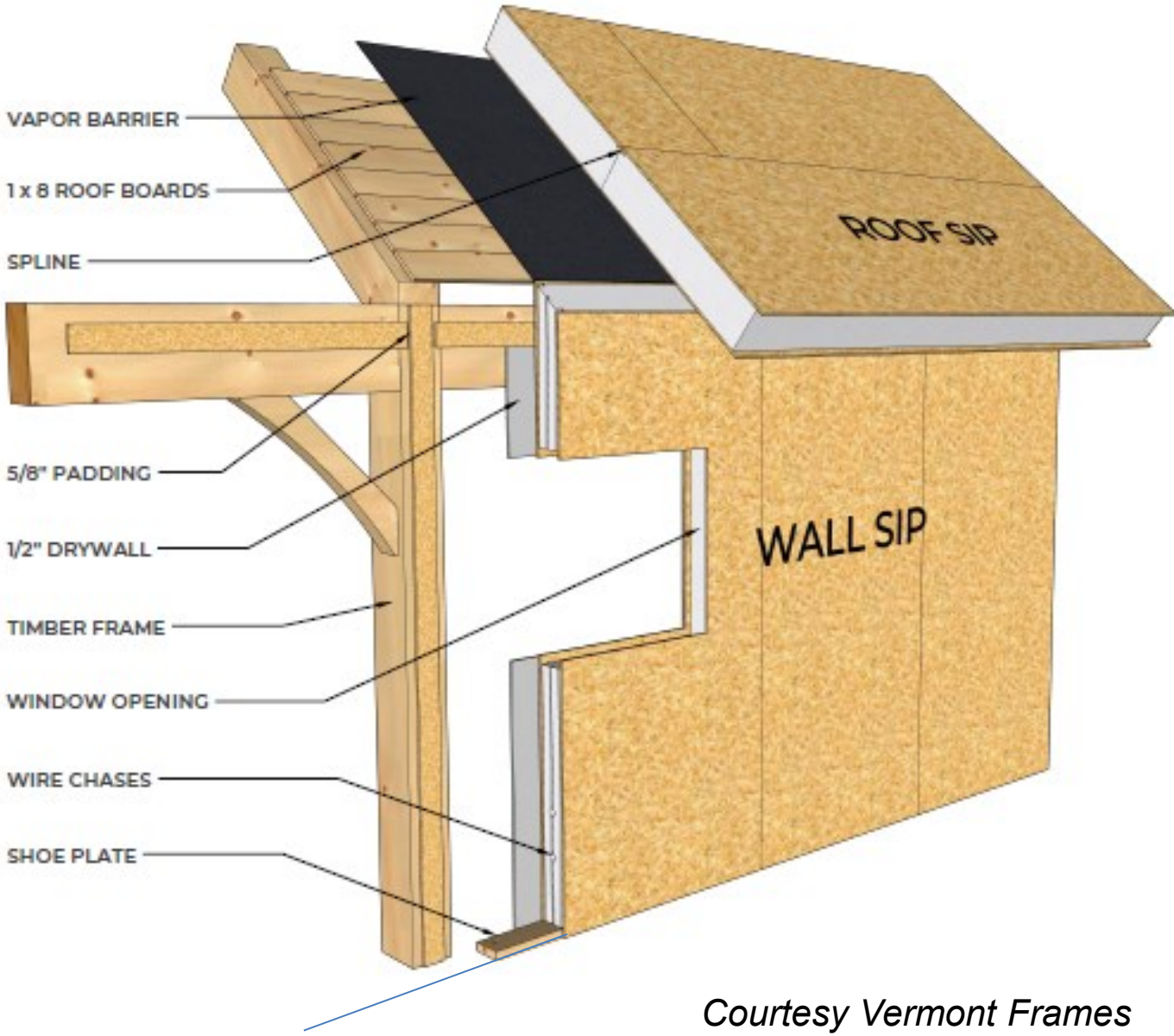
Termite shield at base of panels near grade



F-T shop drawing

Installing the SIPs

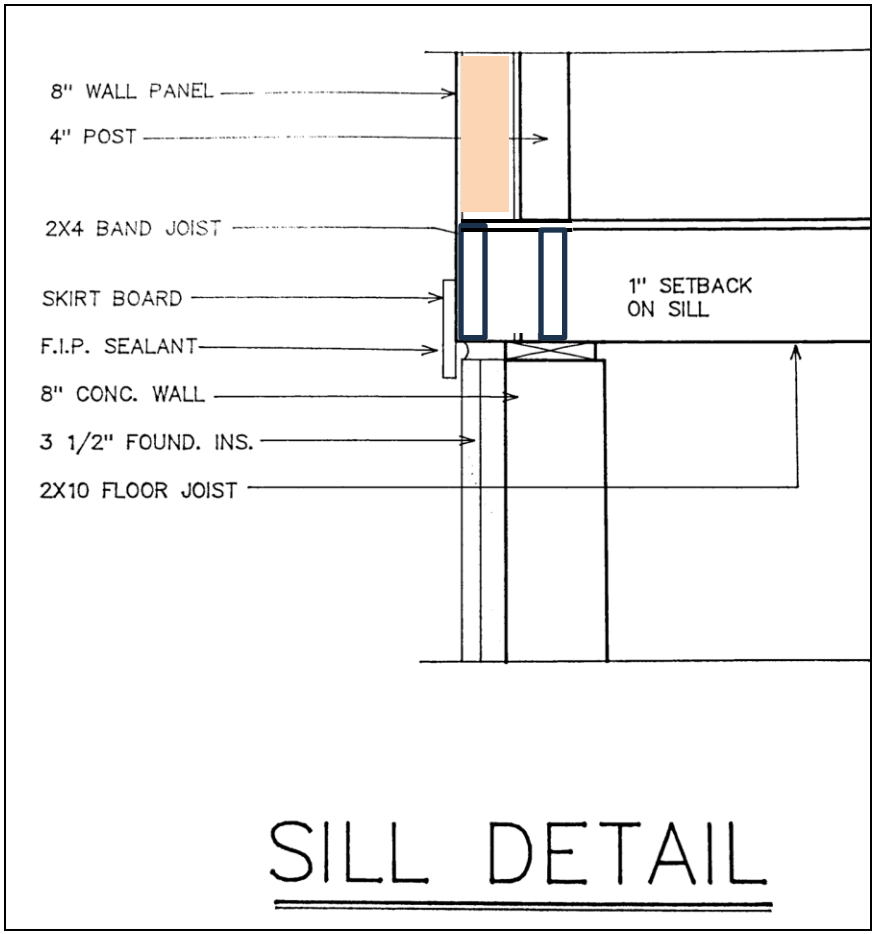
SIPs can be installed on or beside the deck. Beside the deck insulates the rim joist.

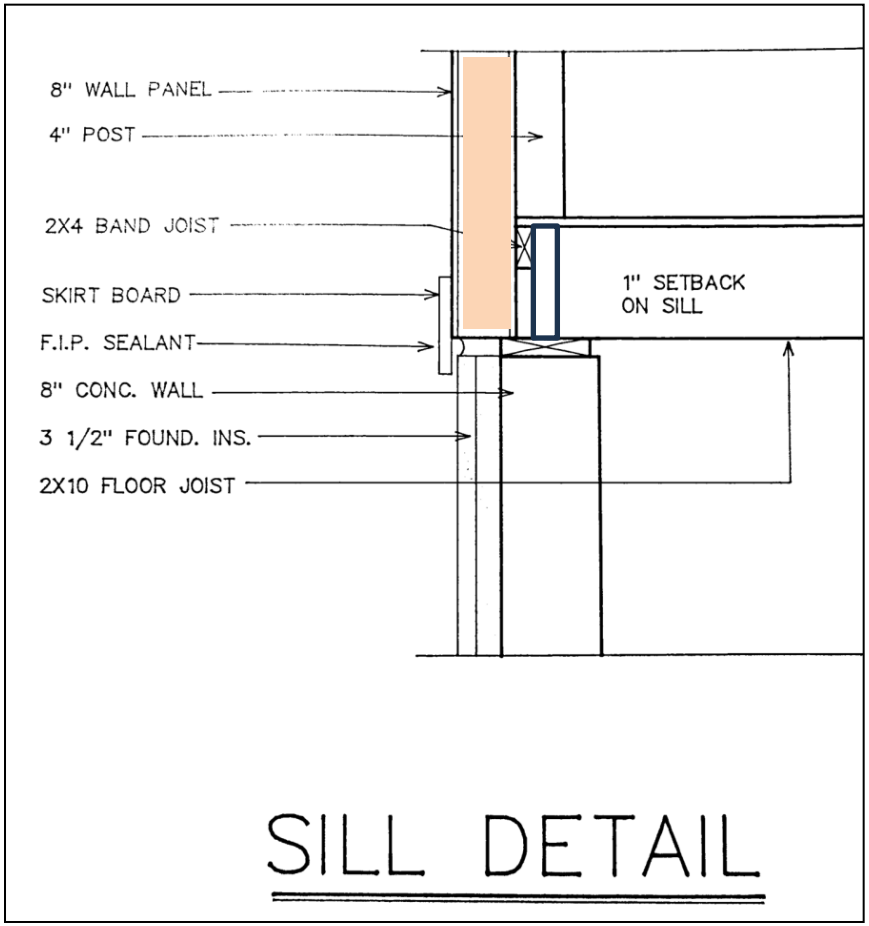


F-T shop drawing

Courtesy Vermont Frames

Installing the SIPs





F-T shop drawing

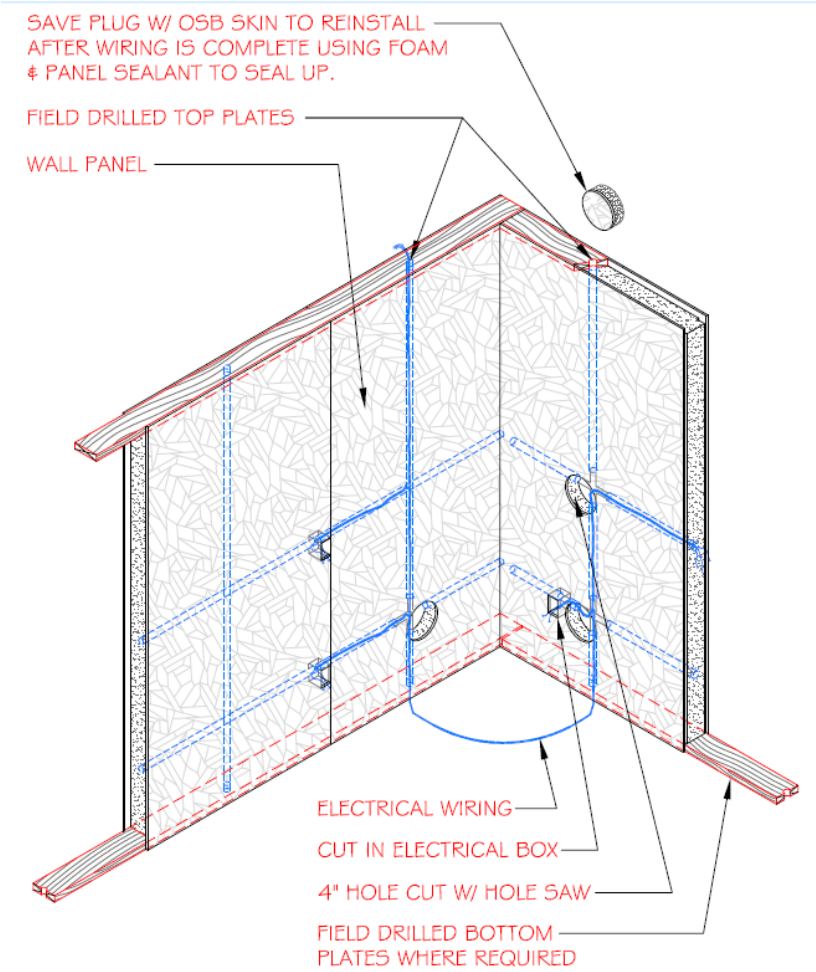
Wiring chases in laminated SIPs

These 4’ wide SIPs have 2’-0” O. C. studs

Wiring SIPs

IMAGE 9.2

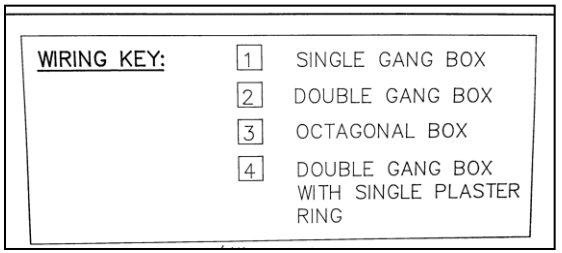
FLOOR SILL PLATE CHASE CUT OUT TO PASS FROM SIP WALL TO BELOW FLOOR.

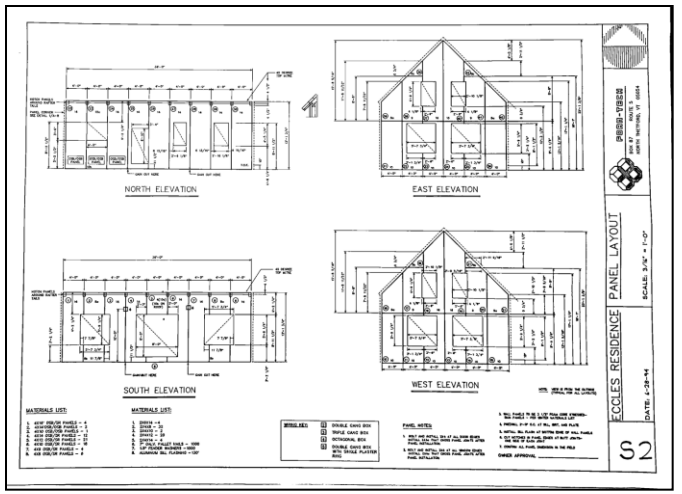


Setting the SIP on the deck does not seal or insulate the rim joist

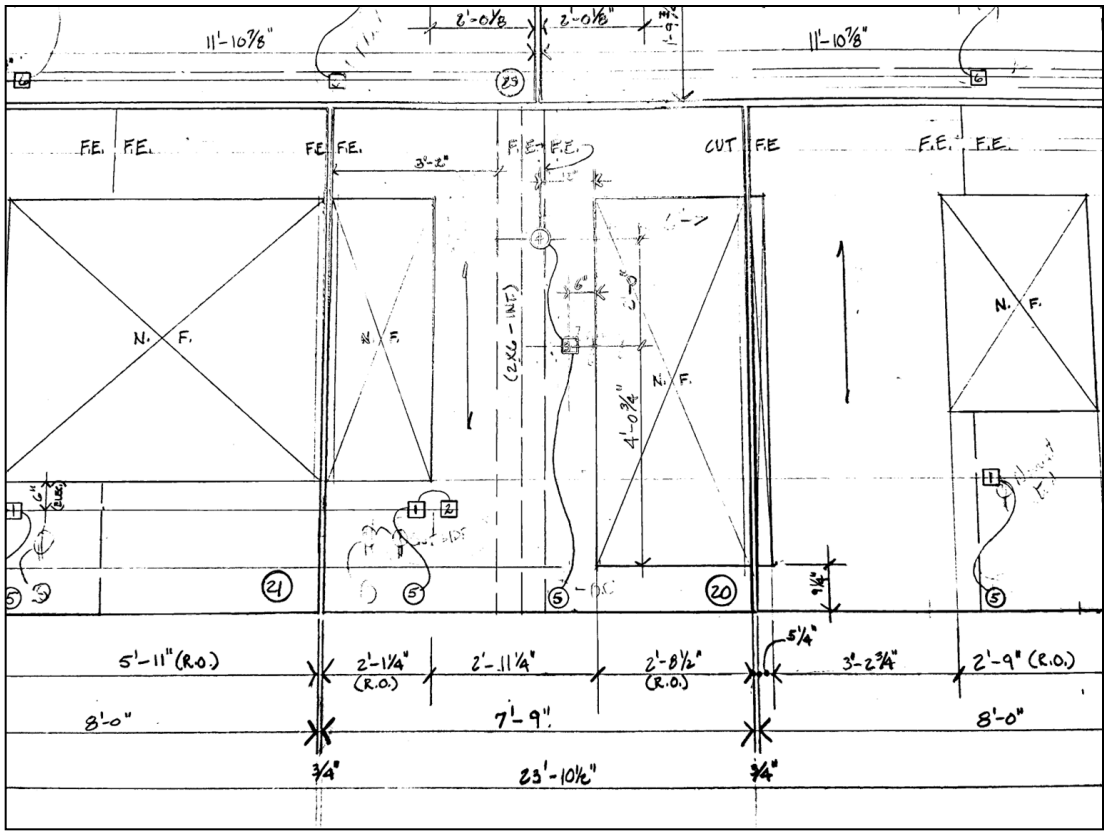
Courtesy SIPA (Structural Insulated Panel Association)

Electrical plan and shop drawings

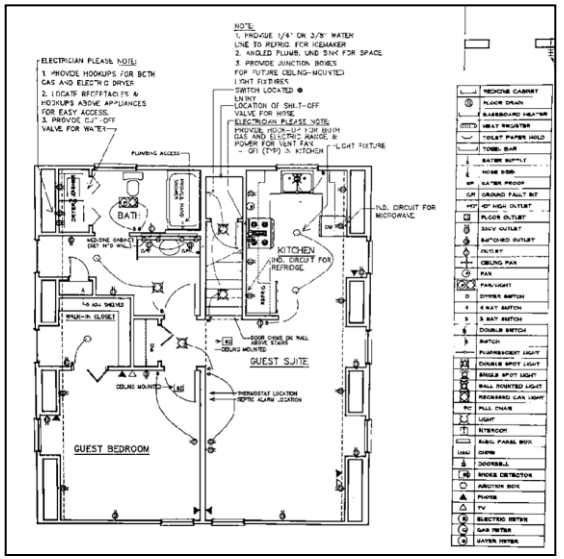




F-T shop drawings



F-T shop drawings



Electrical Plan

6. Why can SIPs perform better than conventional construction?

Why can SIPs perform better than conventional construction?

a. SIPs provide continuous insulation - Less thermal bridging
b. Usually faster overall installation
c. Better quality assurance for the foam at the factory
d. Can be manufactured in a factory with a controlled environment prior to the construction

Two days from open frame to enclosed

Pre-manufactured 4’ wide Winter panels – Panels were ordered in various lengths to reduce waste – cut more precisely on site

Lyme, NH, 1988

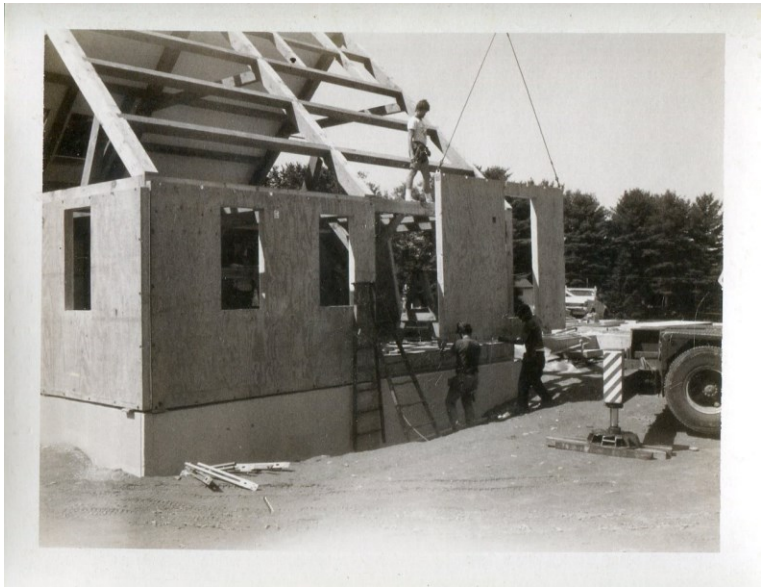
Two days from open frame to enclosed

Light frame extensions for soffits

These wall panels cover the rim joists

Randolph, VT, 1991

Custom SIPs, Prewired



Shop drawings and electric plans make this work

Hanover, NH, 1986

Custom SIPs, Prewired

Pre-painting to avoid cutting in around the posts and beam frame

Still no melt 31 years later - Winter 2017

Adaptive reuse – SIPs on an 1800s barn

The SIPs were ordered and manufactured during this part of the project schedule

New foundation and guano removal

Hartford, VT, 1983

Exterior Panel Wall System

Spray foam in the attic

Window openings come next

SIPs can be installed without a crane in some cases

Nailtab SIPs on HP enclosure

Marc's central heating system design in place

The heating system backup never ran

Blower door test result = .06 CFM50/sf

Nearly 100% of space heat is provided by computers, solar gain, and lights (Energysmiths)

P.E. Energysmiths, Meriden, NH.

Hartford, VT - 1983

Exterior Nailtab SIP Wall System

SIPs C-C PUF (6” = R-40)

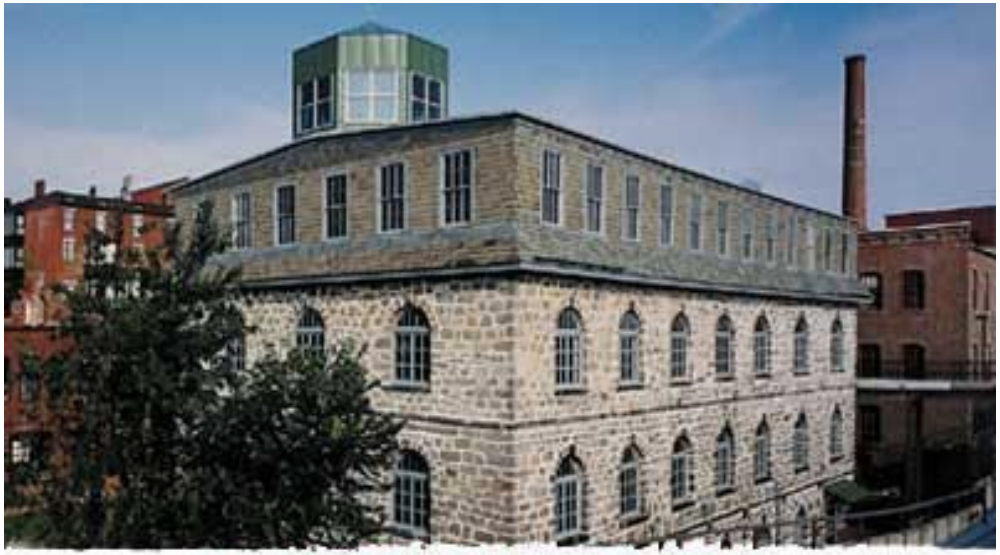
ACH nat. <.03 (1984)
KWH/SM/Yr. <100

7. The flexibility of SIPs

The flexibility of SIPs

a. Can be a vented or unvented roof
b. Can be installed on timber-framed construction – Most common for me
c. Can be installed on steel-framed construction – typically roofs
d. Can be installed on stick-framed construction – Most flexible – easy wiring and plumbing
e. Can be a stand-alone structure - basically prefab
f. Can be used when reversibility is required

Historic reversibility

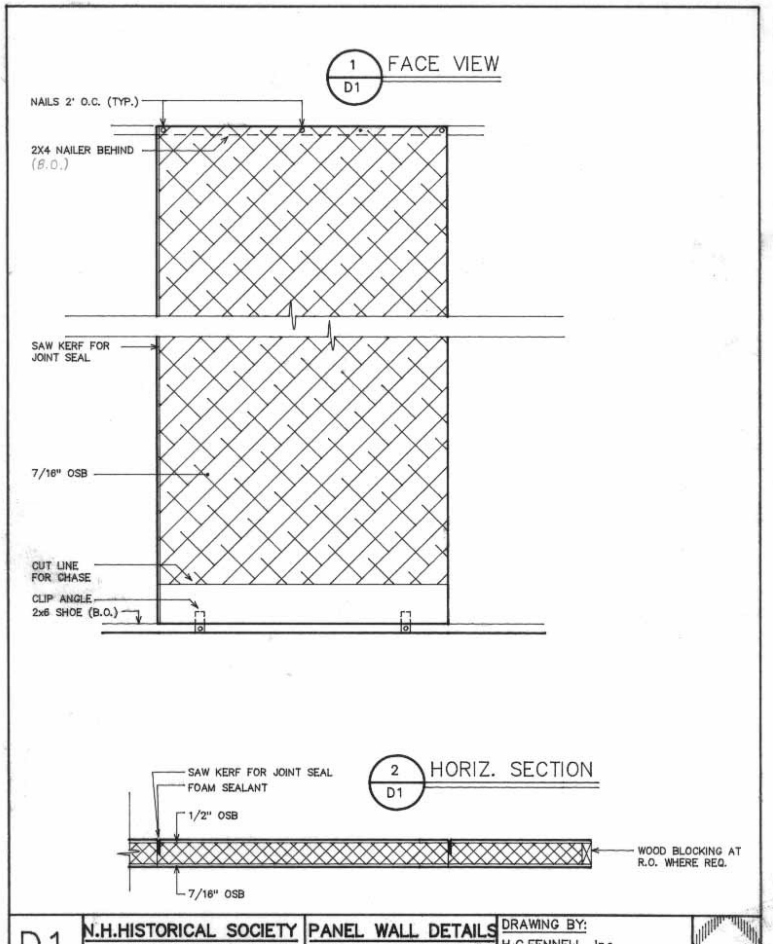


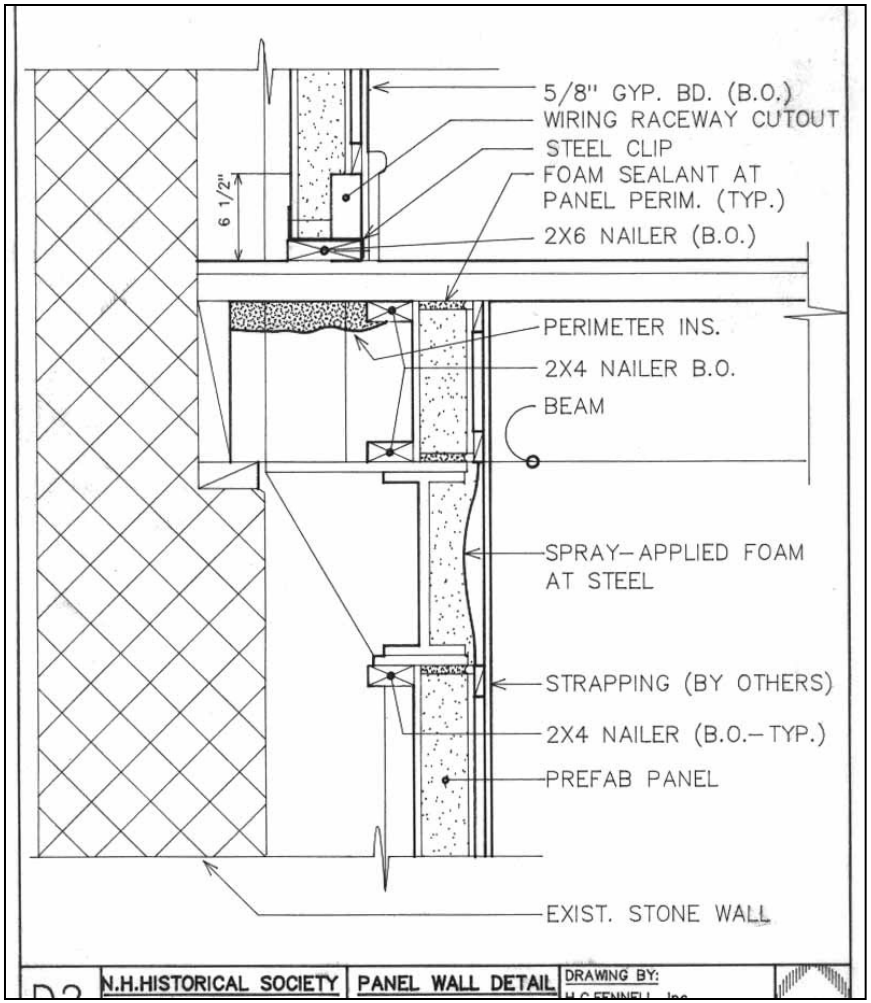
20,000 square feet of renovations and rehabilitation on four floors
Construction cost: $1,800,000
Completion: 1994

High-need indoor climate for this museum

New Hampshire Historical Society

Historic reversibility – SIPs inside foundation





F-T shop drawings - 1993

The hysterical society wanted reversability

Custom panels for long roof long spans

Structural SIPs with full-thickness panel joint sealants

York, ME - 1986

Custom panels for long roof spans

York, ME - 1986

Custom panels for long roof spans

York, ME - 1986

SIPs on stick-framed walls

SIPs attached to the timber frame and the studs

Courtesy Vermont Frames

SIPs on stick-framed construction

SIPs attached on the outside of stick framing allows complete flexibility with the utilities in the wall framing space.

Woodstock, VT - 1984

SIPs retrofit of stick-framed residence

SIPs attached to the rim joists and the studs

North Thetford, VT 1999

Adaptive reuse – SIPs inside an 1800s barn

Stabilize the foundation

The old barn - before

Thetford Hill, VT, 1987

Incognito windows and SIPs - after

Adaptive reuse – SIPs inside 1800s barn

Loft apartment, 1987

Thetford Hill, VT, 1987

8. What are the problems with SIPs?

What are the typical causes of SIP problems?

1. Roofing and flashing bulk water leakage
2. Air leakage
3. Convection within the panel joint gallery
4. Thermal bridging – fasteners and light framing

What causes air leakage?

1. Not sealing the panel joints
2. Improperly processing and installing the sealant

What are the typical causes of SIP problems?

Photograph 1: The vertical snow melt lines correspond with the SIP assembly joints

- First, the lack of air sealing at the lower joint panel connections of the SIP assembly…
- Second, the use of dark shingles over an unvented SIP assembly manufactured with an EPS core. EPS experiences dimensional and physical property changes at temperatures above 150 degrees F. Dark asphalt shingles regularly exceed 150 degrees F…

Courtesy Building Science Corp.

What are the problems with SIPs?

- The wiring is more complicated except on stick-built framing
  - A wiring plan is essential
  - Shop drawings are essential
  - SIPs on stick-framed construction have the ultimate flexibility – no wiring is in the SIPs
- Roof SIPs require a crane

Custom SIPs

Roof SIPs require a crane

Randolph, VT, 1991

What are the problems with SIPs?

a. Typical joint seals aren't effective
    i. Superficial foam sealant, caulk, and tape aren't durable and don't eliminate the joint galleries
    ii. Pre-applied sealants are wiped off as the SIPs are installed with a crane
    iii. Blind injection of a joint space is hit or miss
    iv. Splines – wood-to-foam details don't seal, only work in one direction, and they don't work at changes in plane
    v. Gaskets – don't get compressed and don't make corners well

Solving problems with SIPs

b. Joint seals that are full-depth with 2# foam sealant in 3/4” min. gaps provide:
    i. continuous insulation
    ii. space for frame and panel tolerances
    iii. air seal durability
    iv. visual verification that the joint is sealed
c. Filling the joints also eliminates convection spaces (micro ducts or galleries)

9. How to detail SIP installations that work

How to detail SIP installations that work

Transition details

- In the same plane
- At a change of plane or a change of material
- At a rough opening
- At penetrations

Transitions – In the same plane

What are the problems with transitions in the same plane?

Current same-plane panel joint methods:

1. Relying on the splines to make a seal
2. Blind injection of a small space between the splines
3. Superficial application of caulking

It’s all in the details – typical OSB SIPs

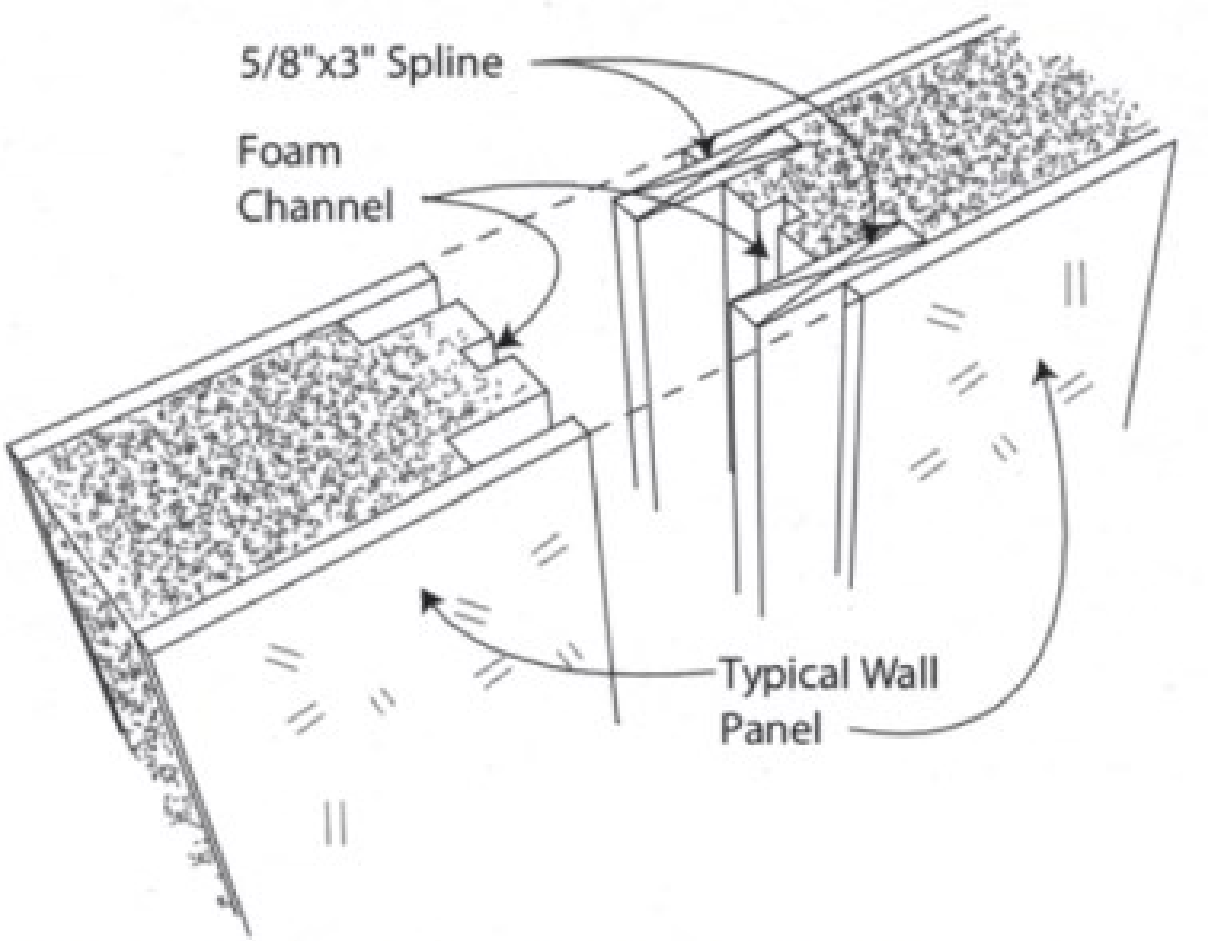
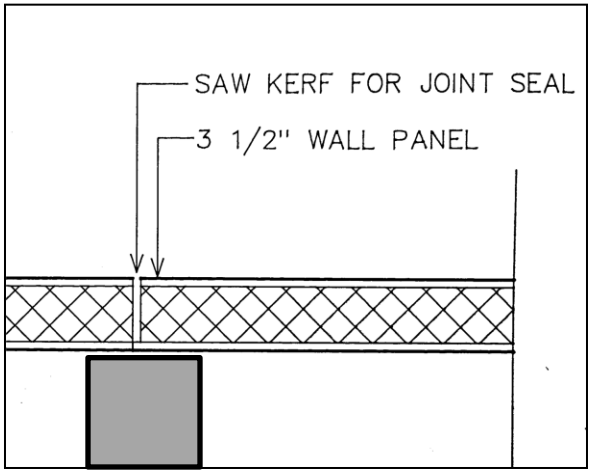


Figure 12. Dual Plywood Splines. *Dual plywood splines are typically used to join panels.*

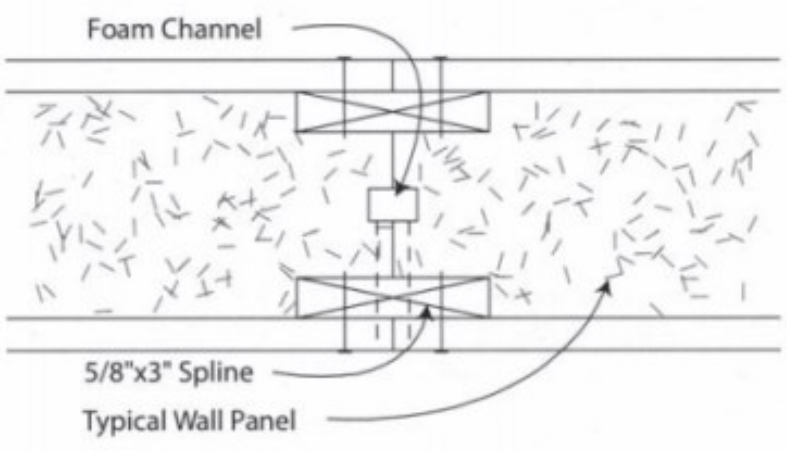
F-T shop drawing for detail with no splines and double structural skins



Courtesy Green Mountain Panel

It's all in the details

Figure 13. Dual Plywood Spline Joint. *This figure shows how the factory panel routing creates pockets for inserting the plywood splines and a foam channel for the air sealing detail.*



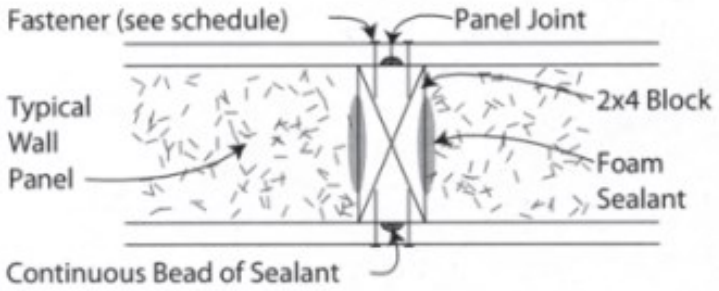
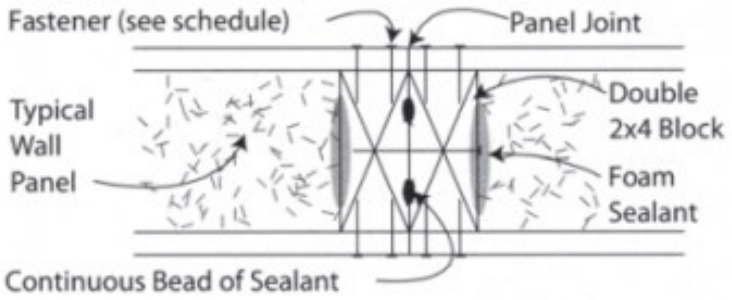


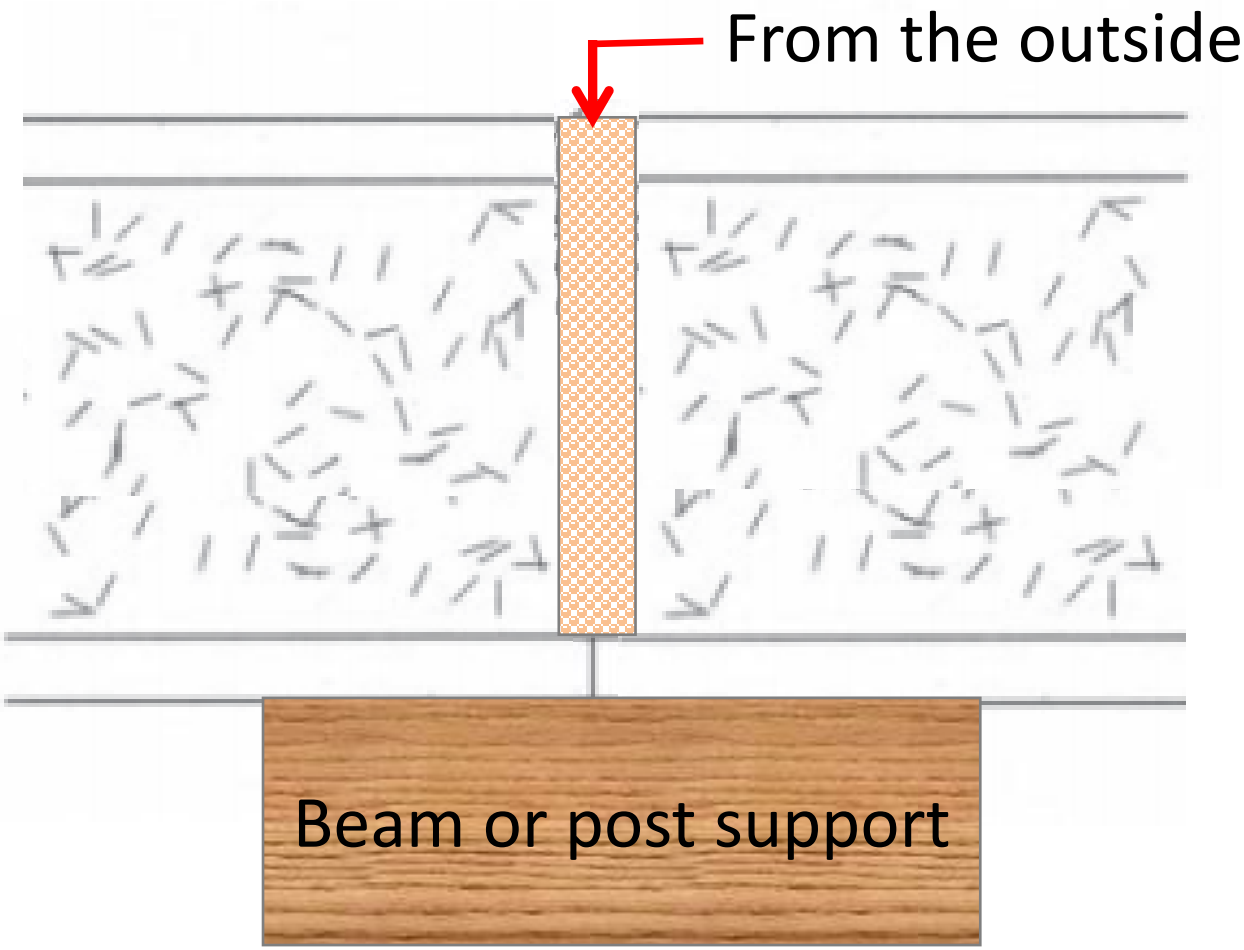
Figure 14. Single Two-by Spline Joint. *Stronger two-by splines may be called for in certain situations where greater load-bearing capacity is required at panel joints.*

Figure 15. Double Two-by Spline Joint. *Stronger double two-by splines may be called for in certain situations where greater load-bearing capacity is required at panel joints.*



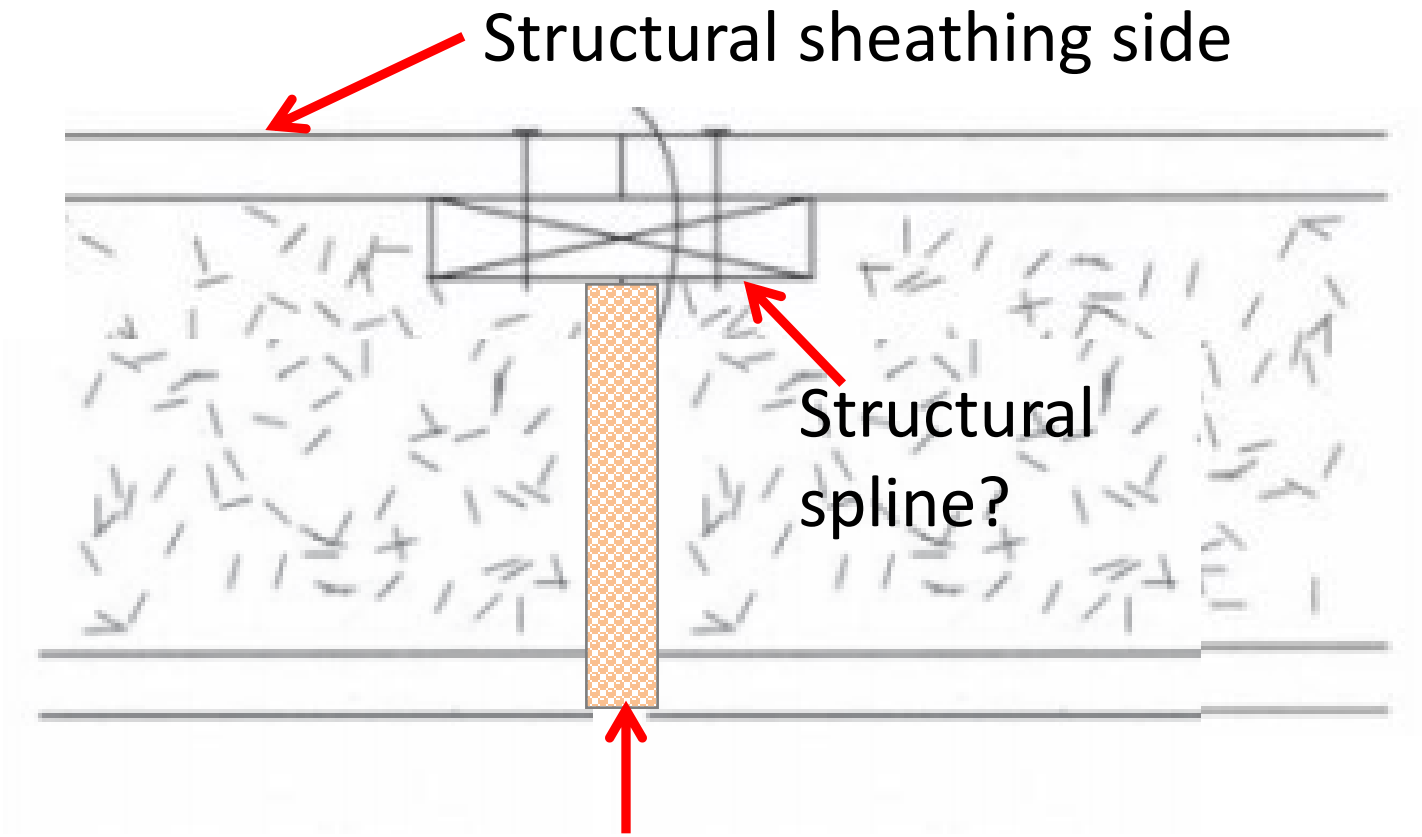
Courtesy Green Mountain Panel

It’s all in the details



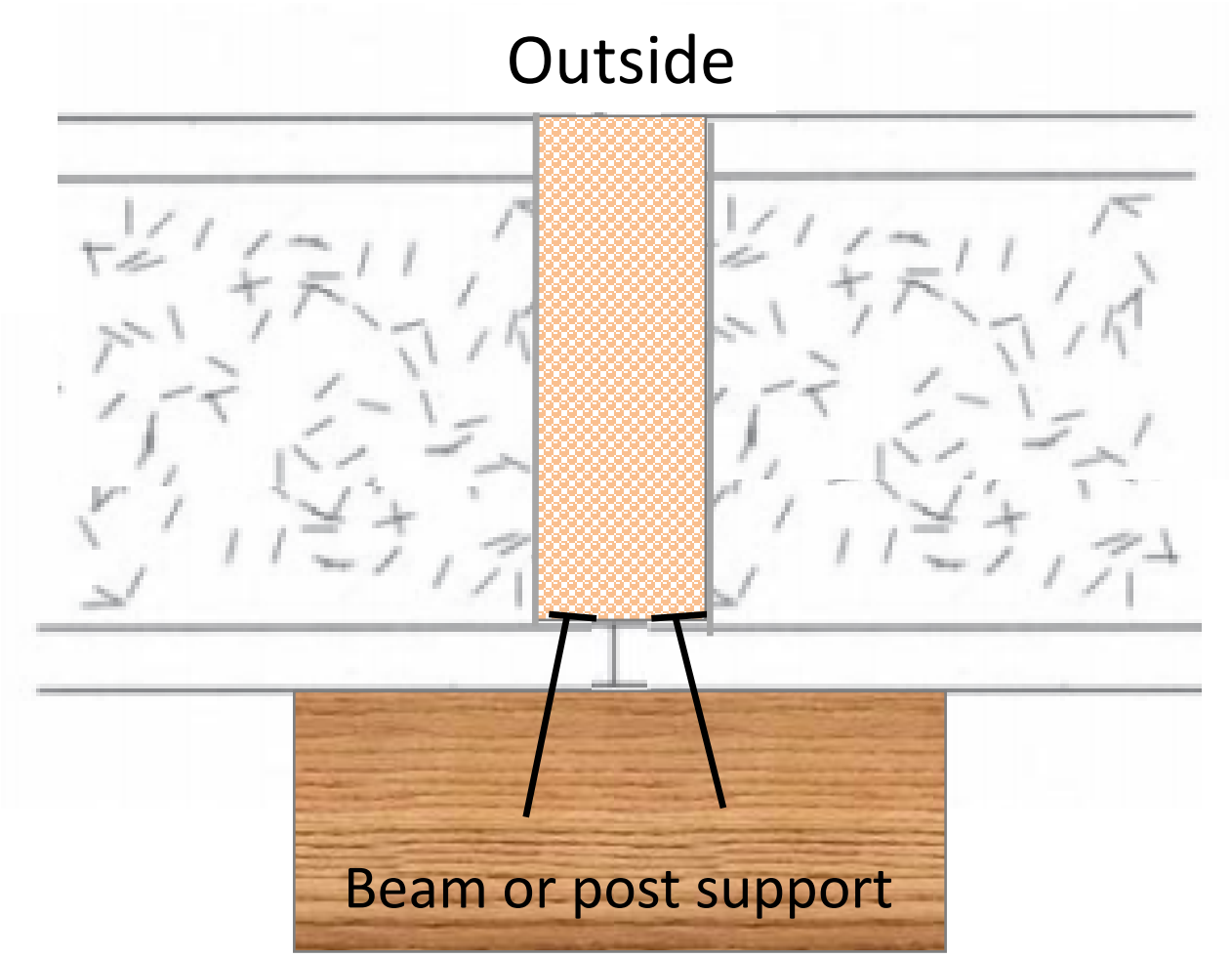
Full-thickness seal – provides visual QA – eliminates convection within and through the panel joint galleries

It’s all in the details



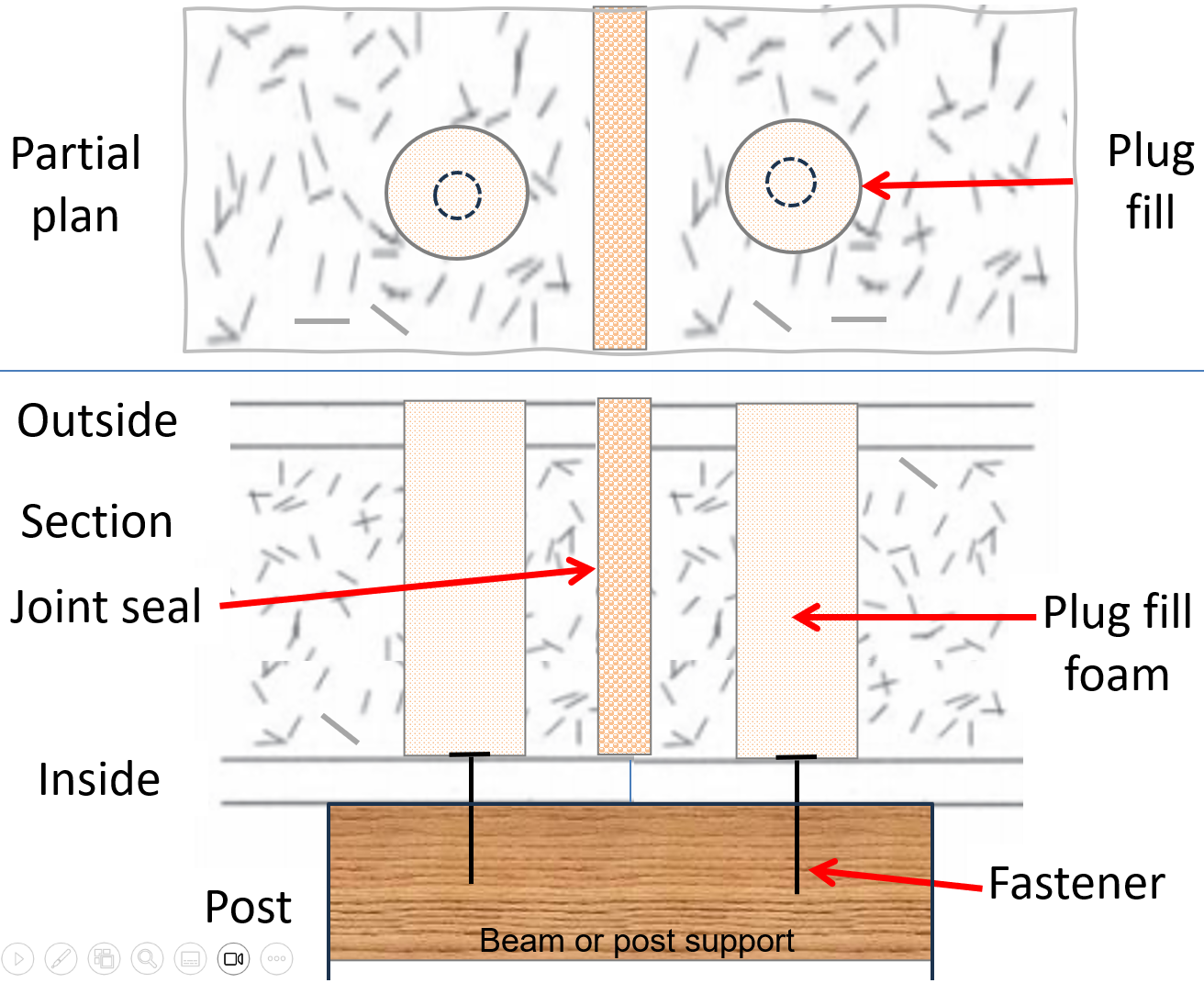
Near full-thickness seal – One spline if necessary for skin alignment – no post or rafter

It’s all in the details – Fastening only the inside skin eliminates the fastener thermal bridging

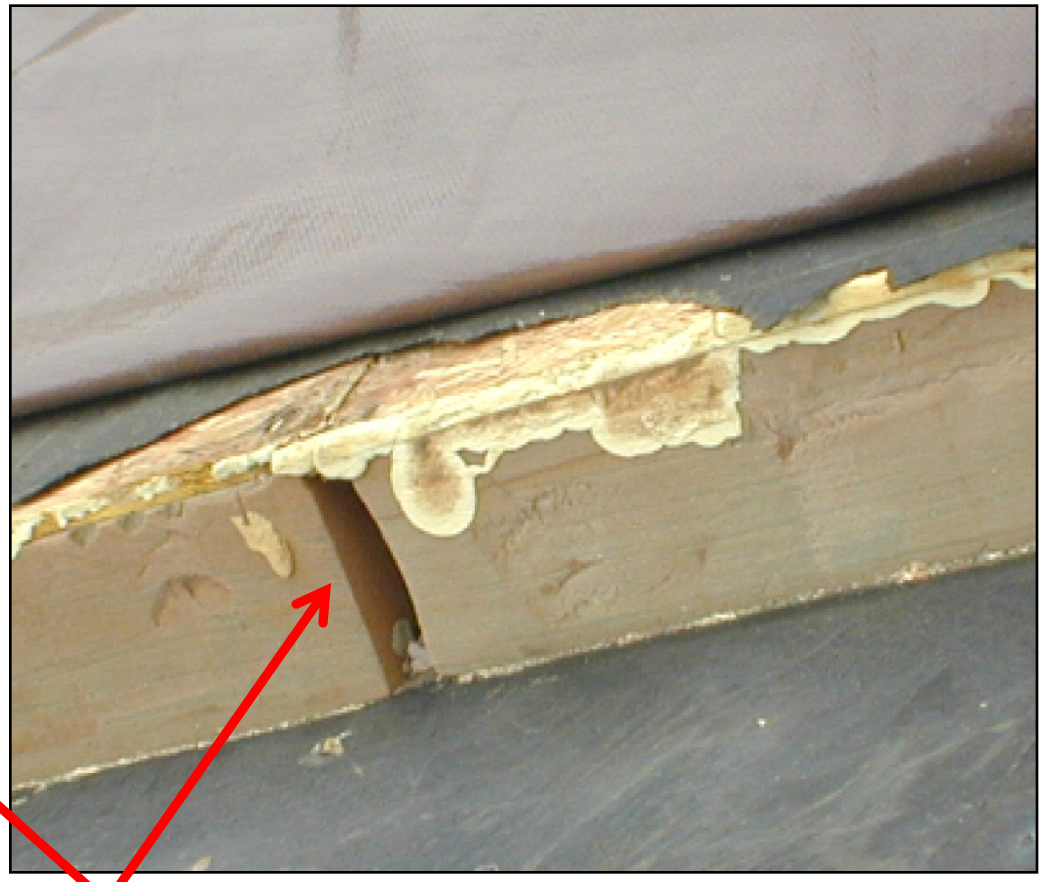


Full-thickness seal – provides visual QA – eliminates convection within and through the panel joint galleries

It’s all in the details – Fastening only the inside skin eliminates the fastener thermal bridging



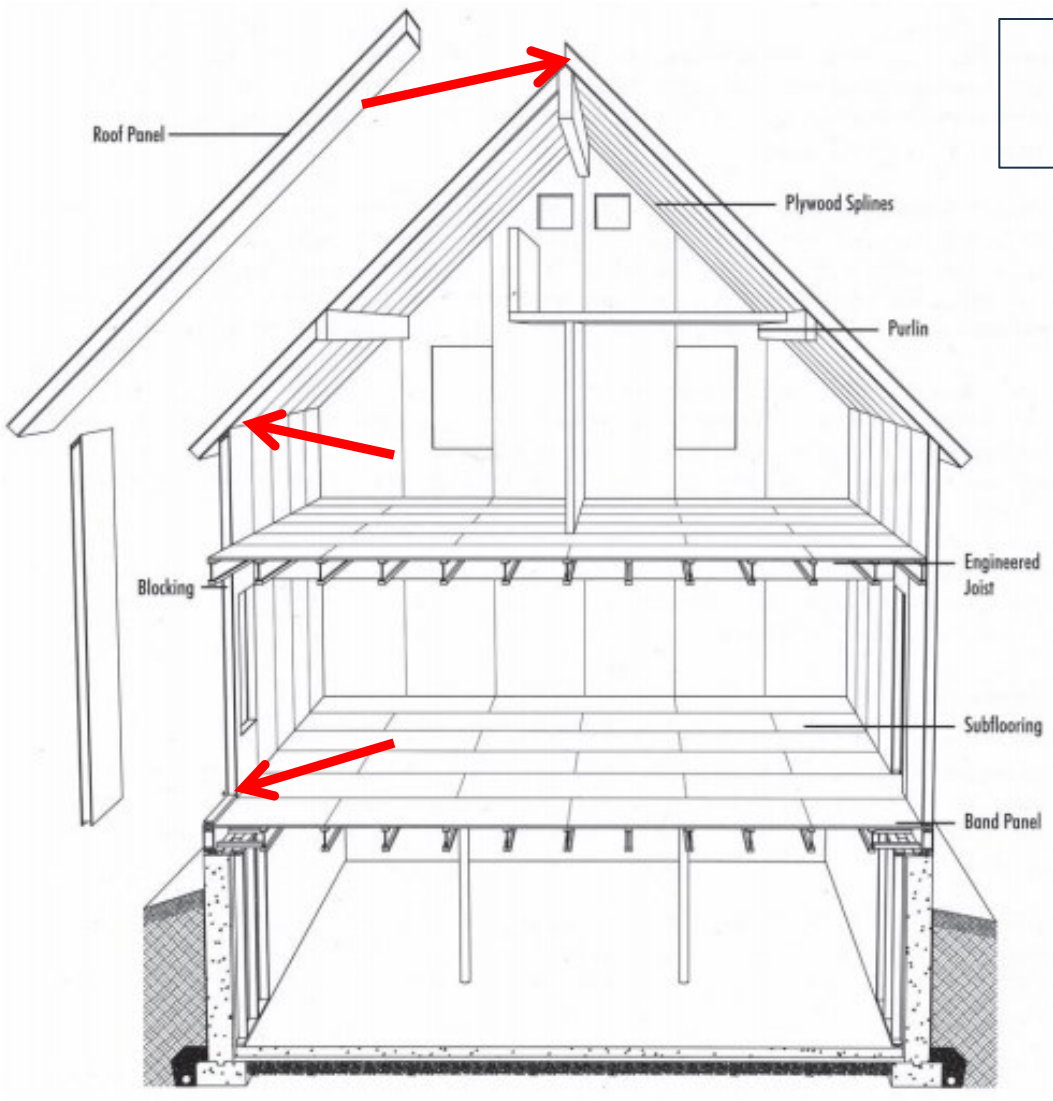
Superficial application of caulking



Panel joint convection gallery
below superficial caulk seal

Transitions – change of plane and change of material

It’s all in the details



Horizontal corners also

Courtesy Green Mountain Panel

It’s all in the details

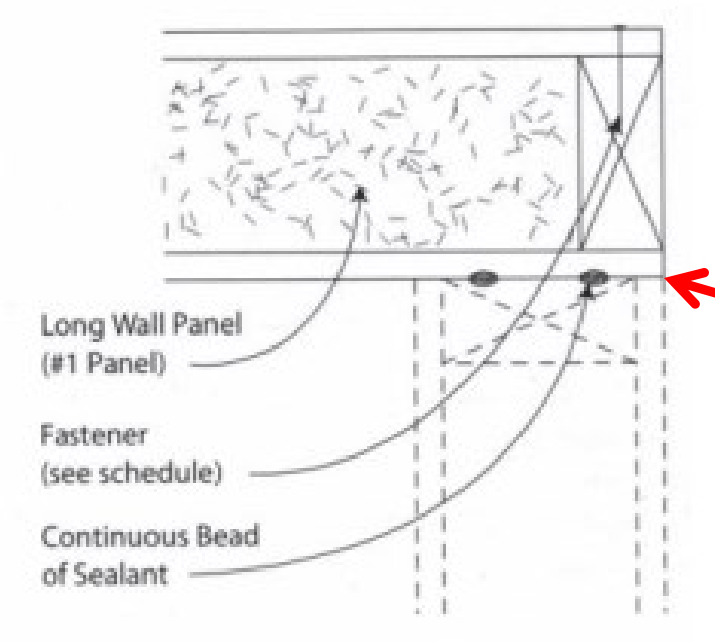


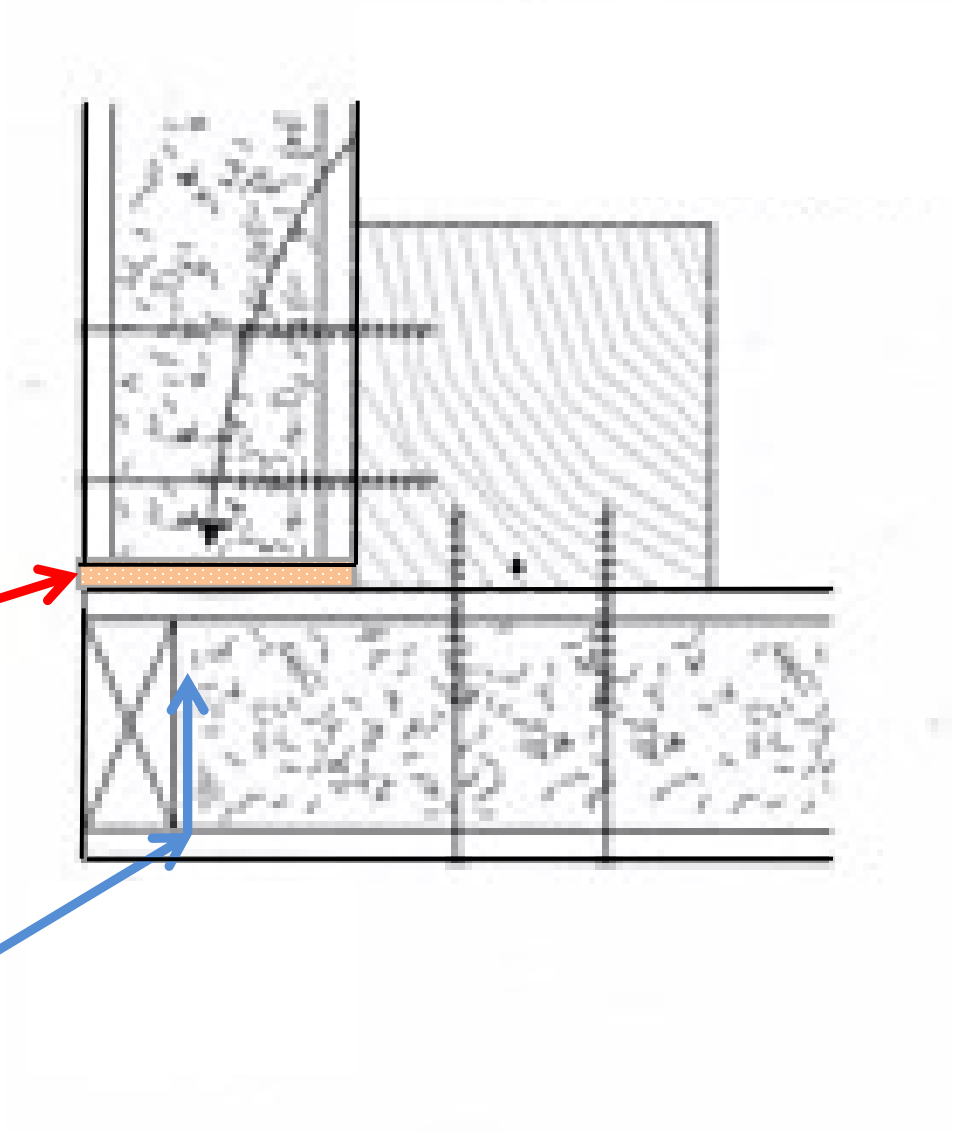
Figure 19. Panel Corner Joints. *Note the beads of adhesive connecting these two panels.*

This detail does not accommodate frame or SIP tolerances

Courtesy Green Mountain Panel

It’s all in the details

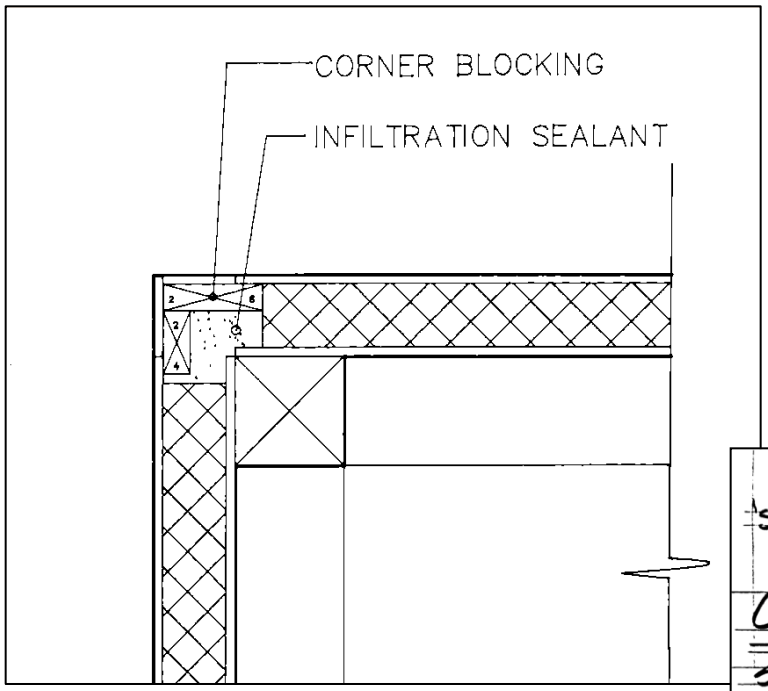
This detail accommodates frame tolerances and provides a gap for foam sealant (FS)



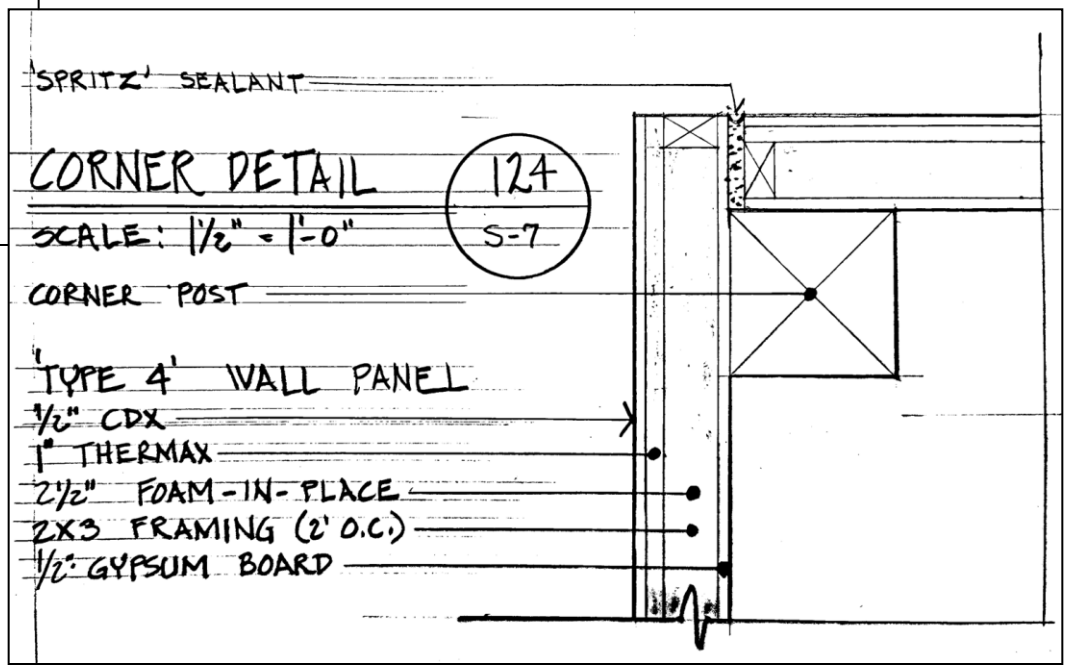
Hold the panel back from the corner in this non-structural location to provide a full-depth sealant gap

Potential air leak through inserted blocking rout is not from the inside to the outside in this detail

It’s all in the details



These details accommodate frame tolerances and provide gaps for joint sealant



HCF shop drawings

It's all in the details

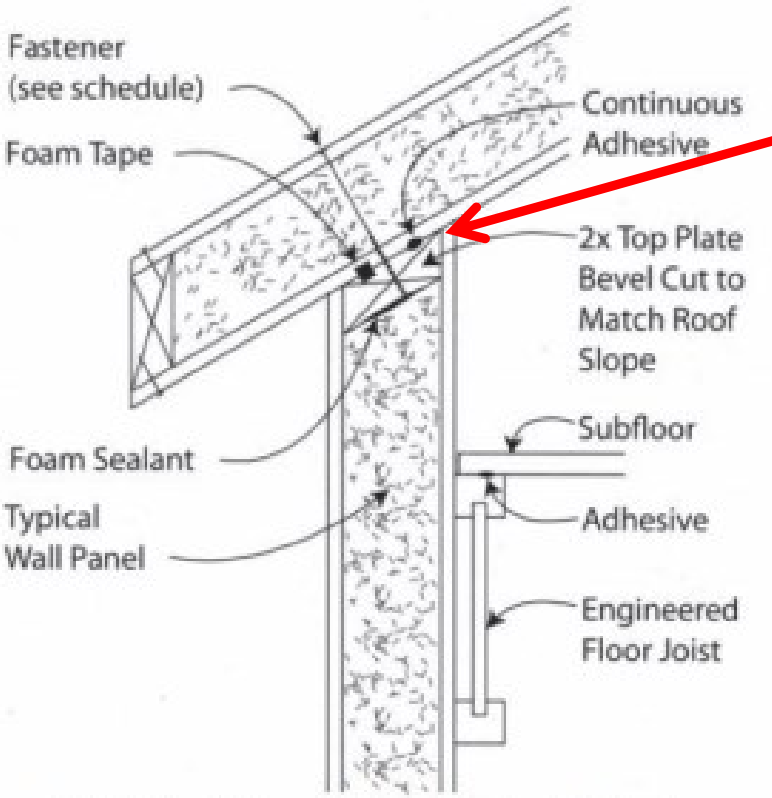
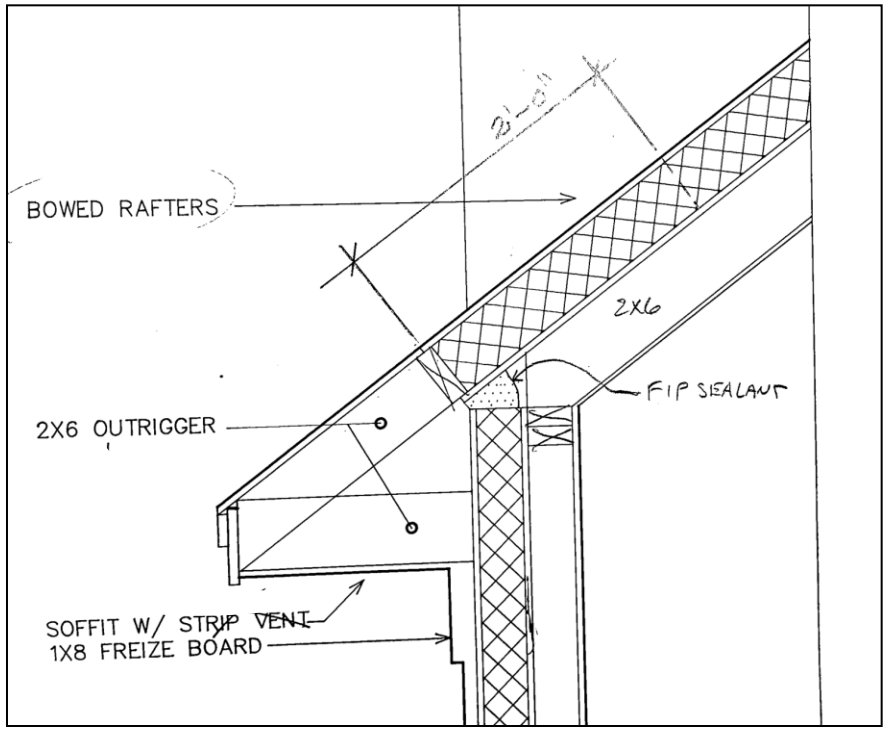


Figure 37. Attic Joist and Floor Detail with Shallow Slope Roofs. *Typically, the floor joists in this situation will run to the gables and not to the eaves.*

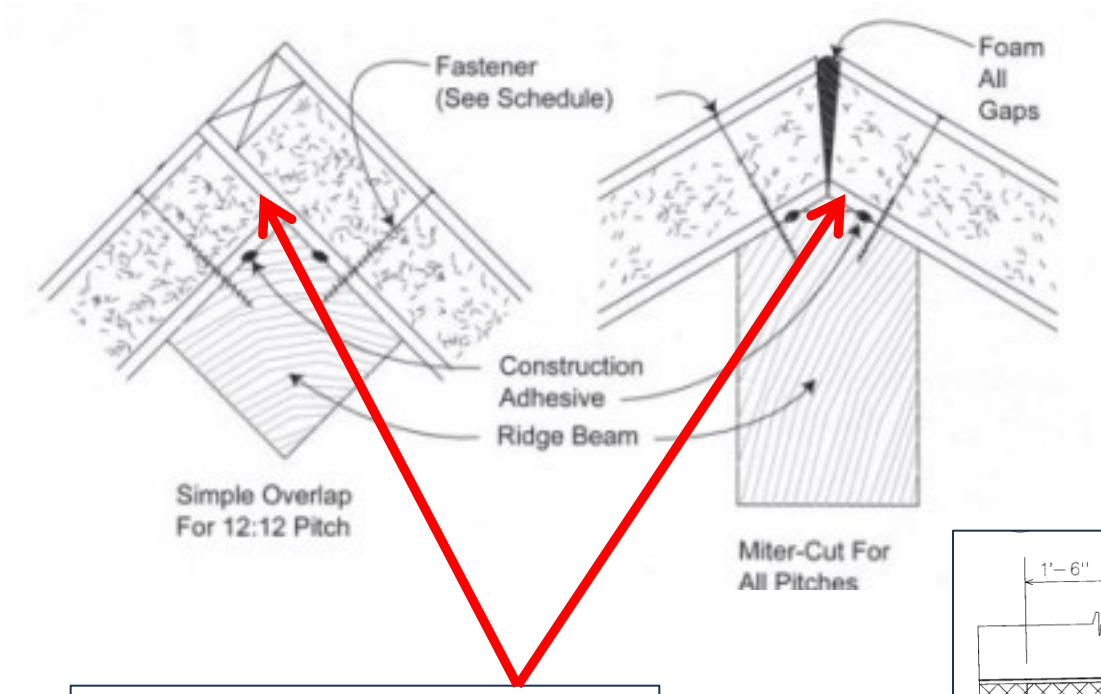
This detail does not accommodate frame or roof angle tolerances. Tolerance and a sealant gap should be designed into the panel layout.



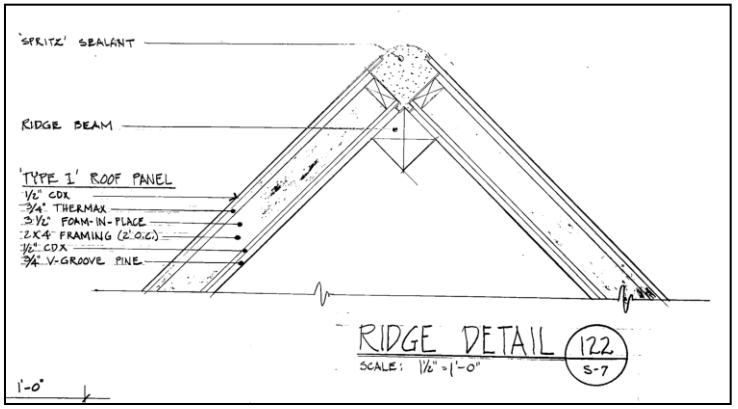
F-T shop drawing

Courtesy Green Mountain Panel

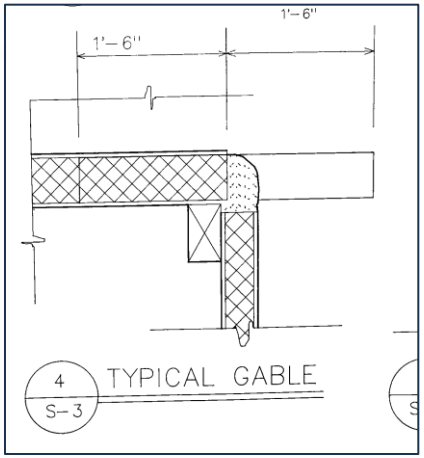
It’s all in the details

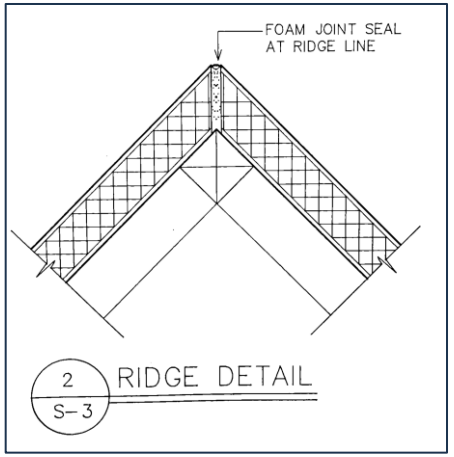


These details don’t accommodate frame tolerances or provide a gap for sealant (FS)



F-T shop drawings





These details accommodate frame tolerances and provide a gap for foam sealant (FS)

Courtesy Green Mountain Panel

It’s all in the details

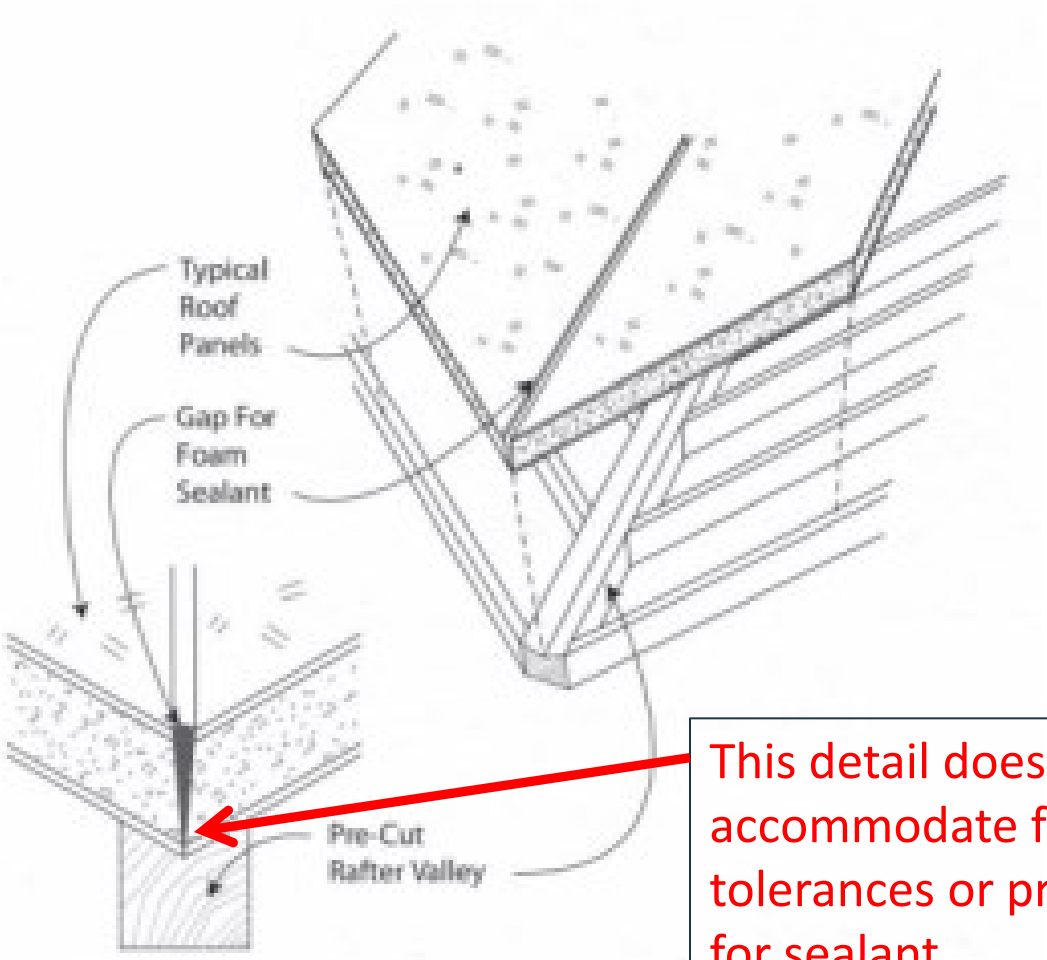


Figure 66. Valley Details. *At roof valleys, panels are joined by making equal miter cuts. For the tightest seal, cut the angles slightly wide (open at the top) or leave a ¼" space and fill the gap with foam sealant.*

This detail doesn’t accommodate frame tolerances or provide a gap for sealant

Courtesy Green Mountain Panel

Transitions at rough openings

It's all in the details

This detail calls for applying the sealant before the panels are lifted into place or the next panel is slid over the framing. What happens to the sealant in this scenario?

You can't slide the panel over half of the window frame if you are at a corner.

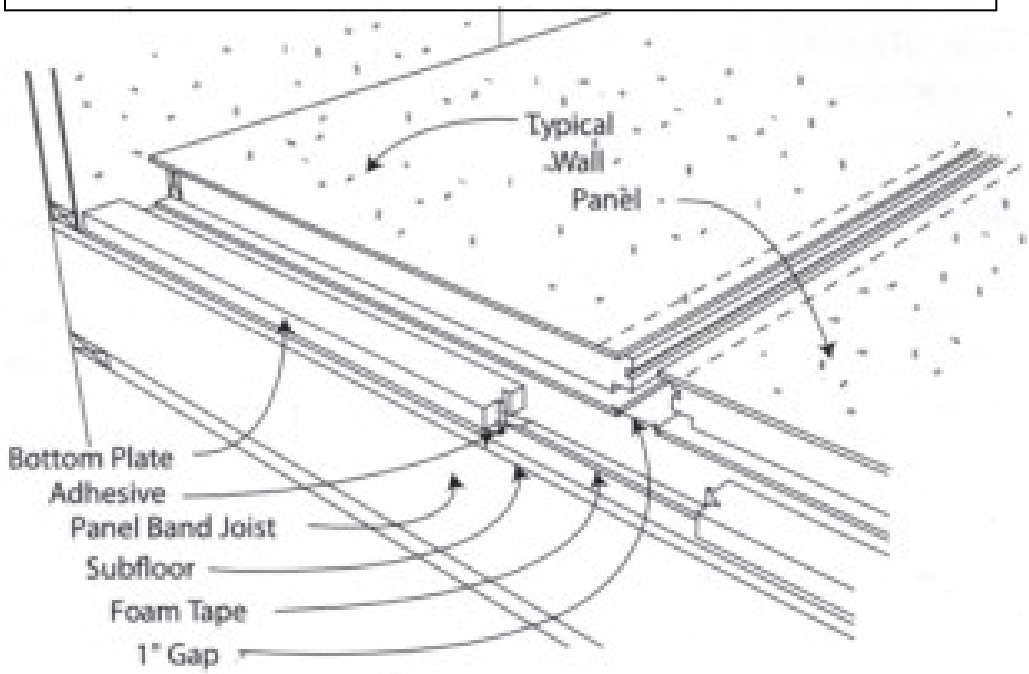
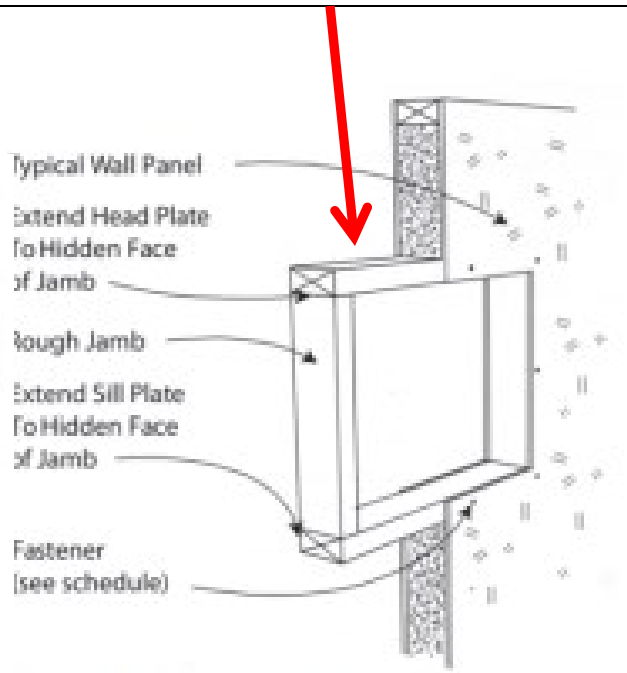


Figure 11. Panel layout for First Wall. *Lay panels out on deck. Join panels before tilting wall up onto bottom plate.*

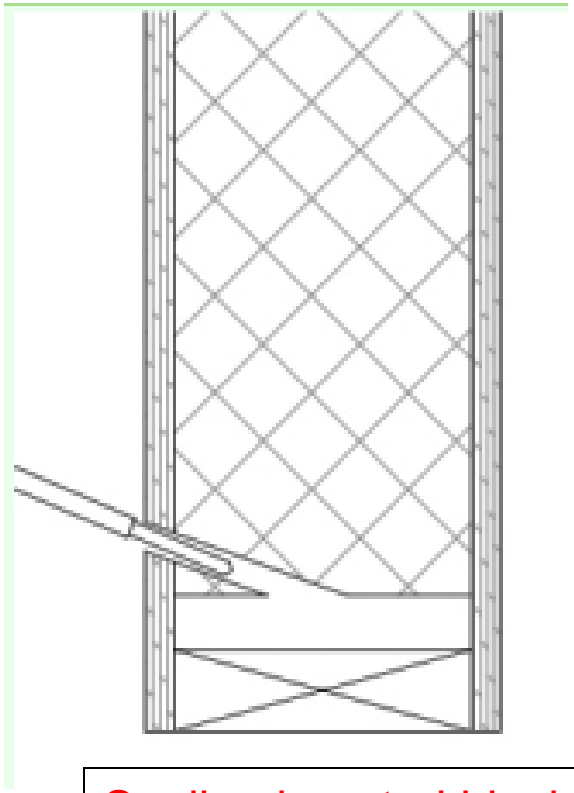


gure 23. Rough Opening for Window.
e perimeters of window openings are routed t 1 ½" and two-bys installed. The sill and ader should overlap side members, as shown.

Courtesy Green Mountain Panel

It’s all in the details

There is no QA for either of these approaches



Sealing inserted blocking with FS requires a deeper rout of the panel edge and lots of holes and precise dispensing of the foam to avoid gaps between the injection points.

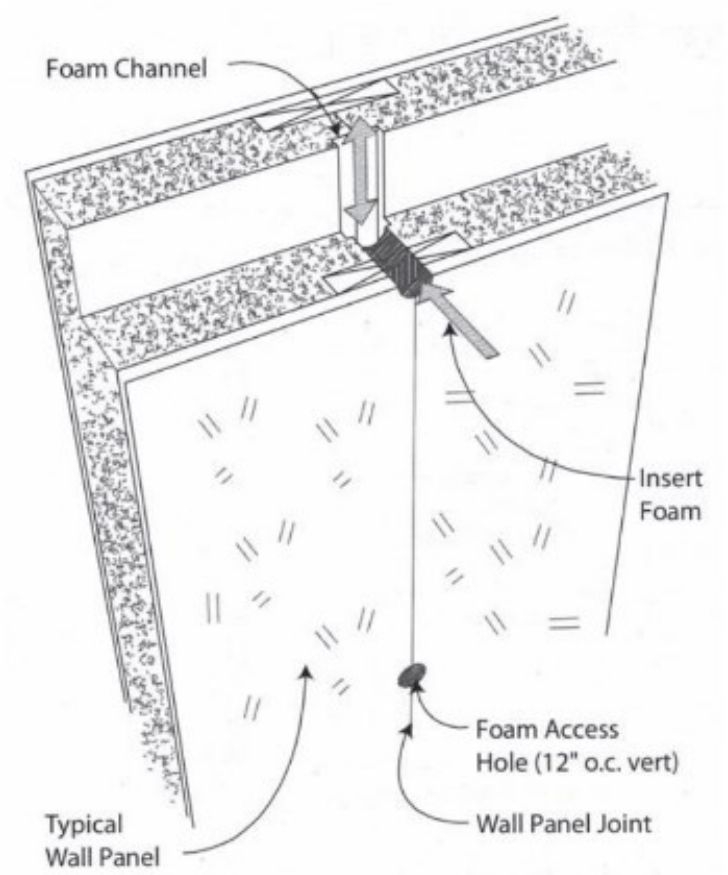
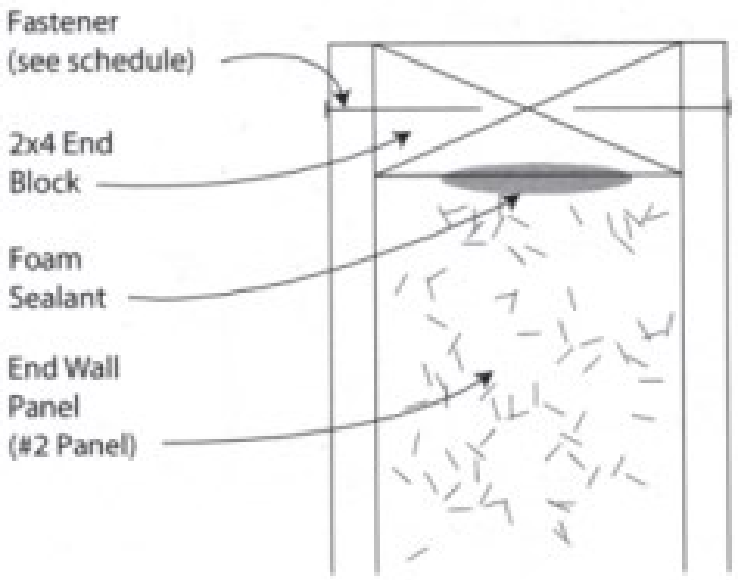


Figure 22. Foaming In-line Panel Joints. *The drilled holes are for foaming of the panel joint, making the air barrier continuous at in-line panel joints.*

Courtesy Green Mountain Panel

It's all in the details

The volume of this space varies and there is no QA recommended for this detail



This detail for sealing inserted blocking with FS requires a precise rout of the panel edge and a precise amount of FS to assure contact of the FS with both materials. Pounding in this blocking into place can displace the FS. There is no tolerance for the rout or the sealant.

Courtesy Green Mountain Panel

Fasteners

Fasteners and thermal bridges

1. Fastening system can determine the overall thermal performance because full-depth fasteners can create significant thermal bridges
2. Truss plates attaching multiple panels use fewer full-depth fasteners
3. Fastening only the inner skin to the structure eliminates almost all of the thermal bridging
4. ARRO II (Antarctica) had no fastener thermal bridging

Fasteners cause thermal bridging

Seven full-depth fasteners at each horizontal framing member, perhaps more along the long edges after installed

Thermal bridging through full-depth fasteners is seen in the frost melt pattern

Fasteners cause thermal bridging

Fourteen full-depth fasteners

Seven full-depth fasteners

Fasteners cause thermal bridging

Using truss plates to attach multiple panels with one screw reduces the number of thermal bridges for SIP installations.

Fewer full-depth fasteners with truss plates

Nailtab SIPs on HP enclosure

Energysmiths, Meriden, NH.

Hartford, VT - 1983

The Nailtab fastening system

Fastening only the inside skin to the frame eliminates thermal bridging.

Zero full-depth fasteners

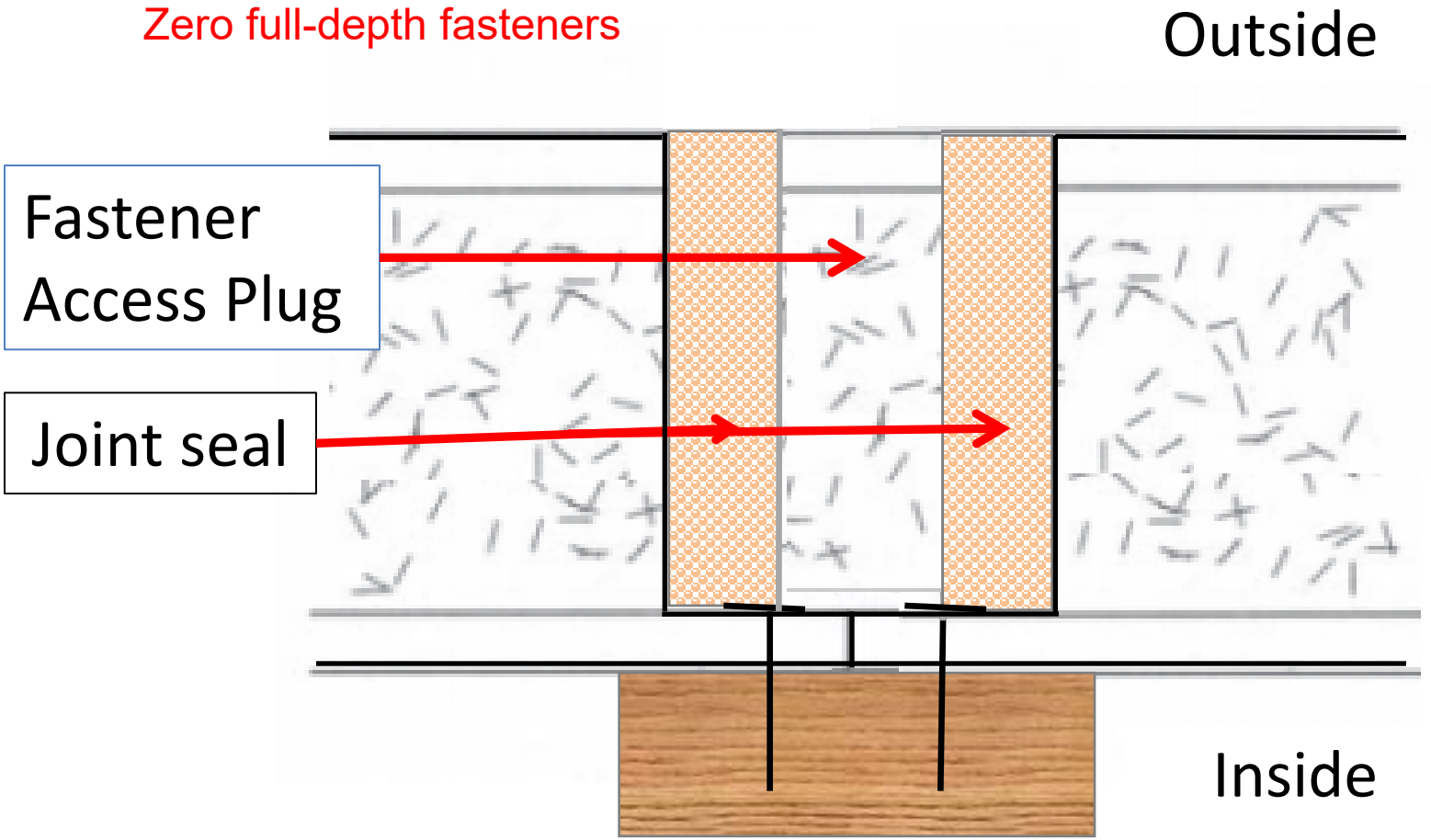
SIPs C-C PUF (6” = R-40)

SIPs C-C PUF (6” = R-40)

Hartford, VT - 1983

It’s all in the details – The Nailtab detail

Zero full-depth fasteners



Full-thickness seal – provides visual quality control – eliminates convection within and through the panel joint galleries

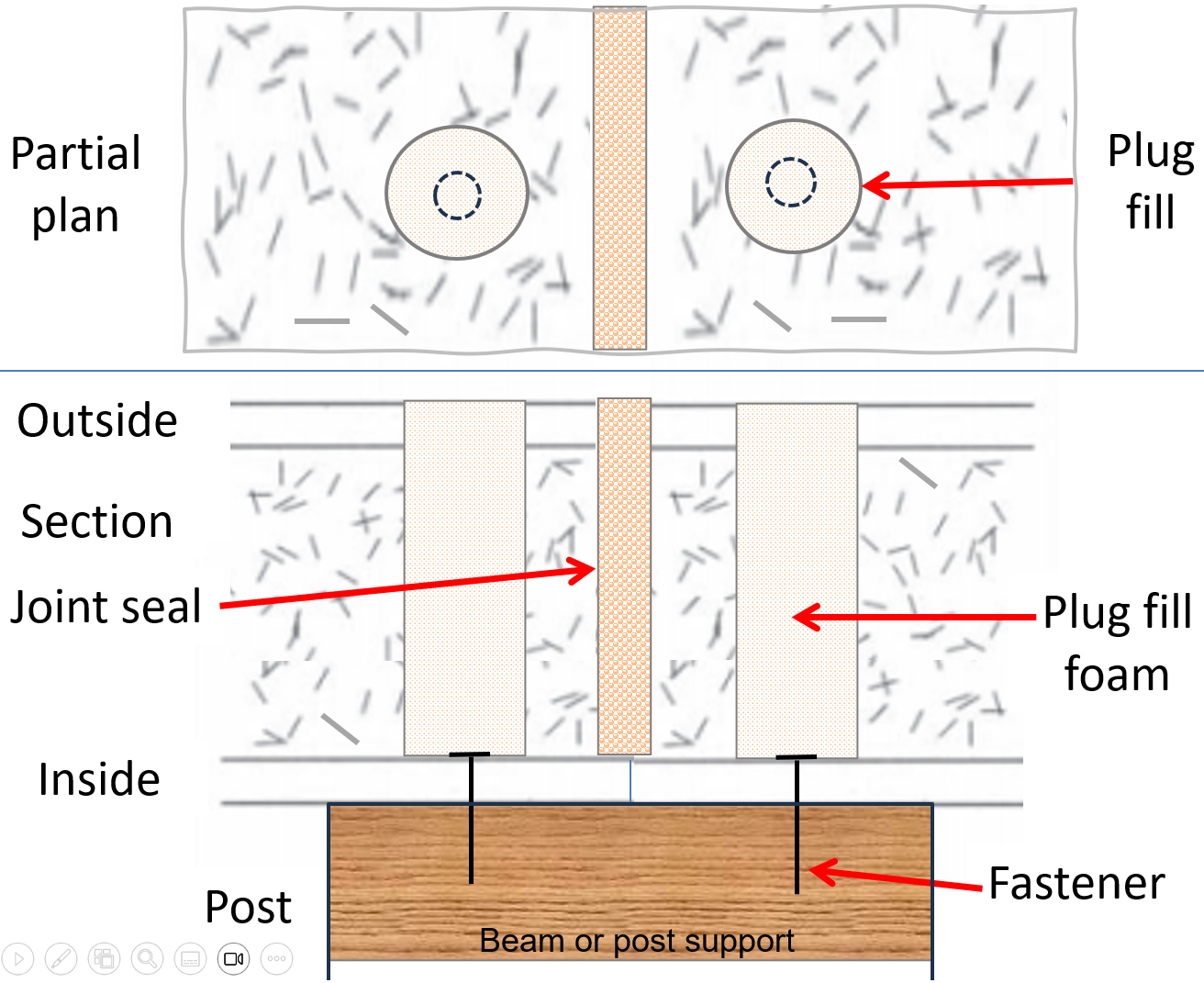
It's all in the details – Stock SIPs

Only the inside skin was attached to the timber frame in this project. The plug fill foam was installed at the same time as the joint seal foam.

1.25" holes drilled through the outside skin and the foam core provides access for attachment.

Randolph, VT, 1991

It’s all in the details – Fastening only the inside skin eliminates the thermal bridging

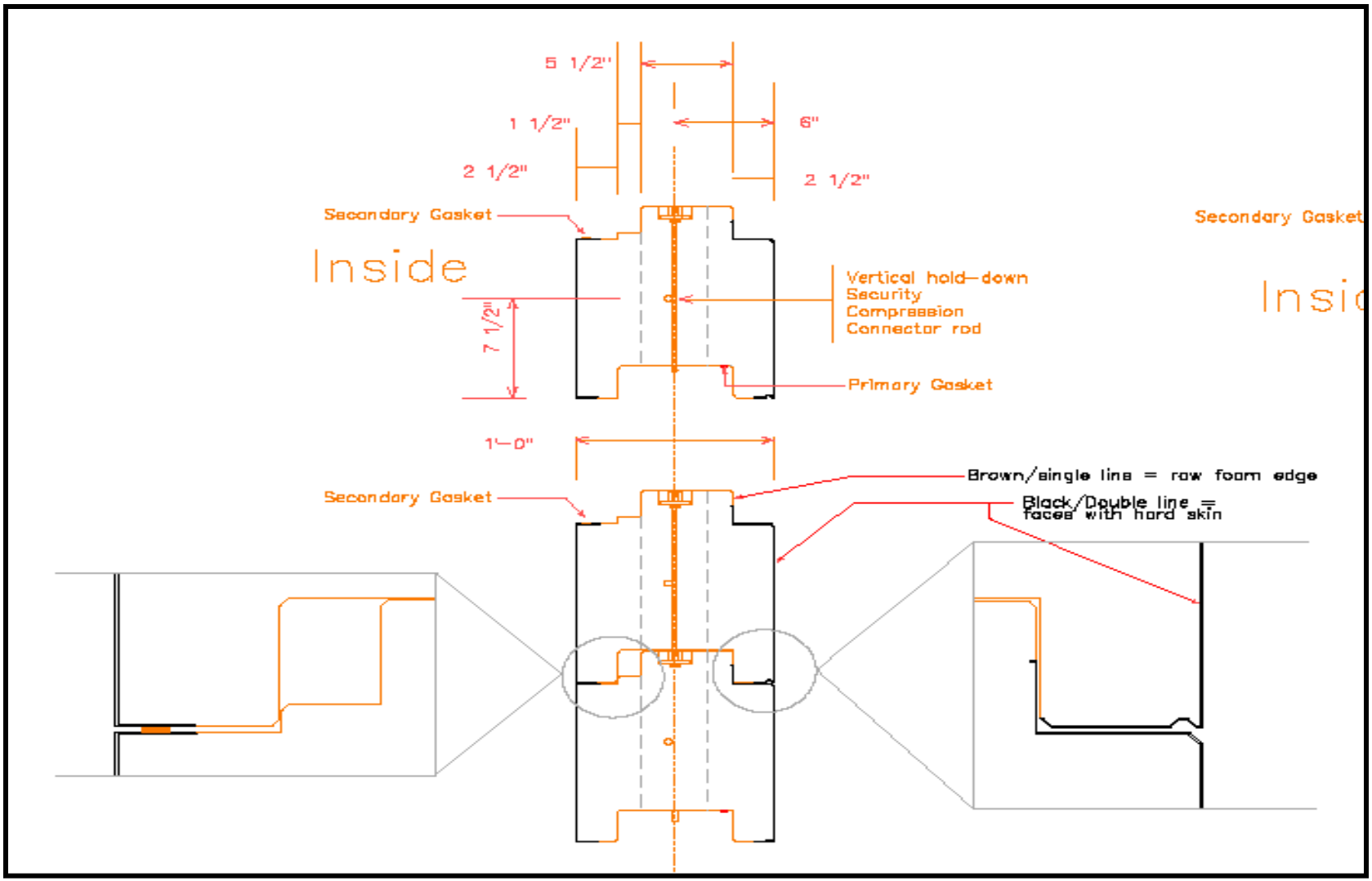


The Summer Environment for the ARRO in Antarctica

The first ARRO Project being tested at the U.S. Cold Regions Research Environmental Laboratory

~200 watts total energy for –70F outside, 70F inside.

Arro II has no full-depth thermal bridges



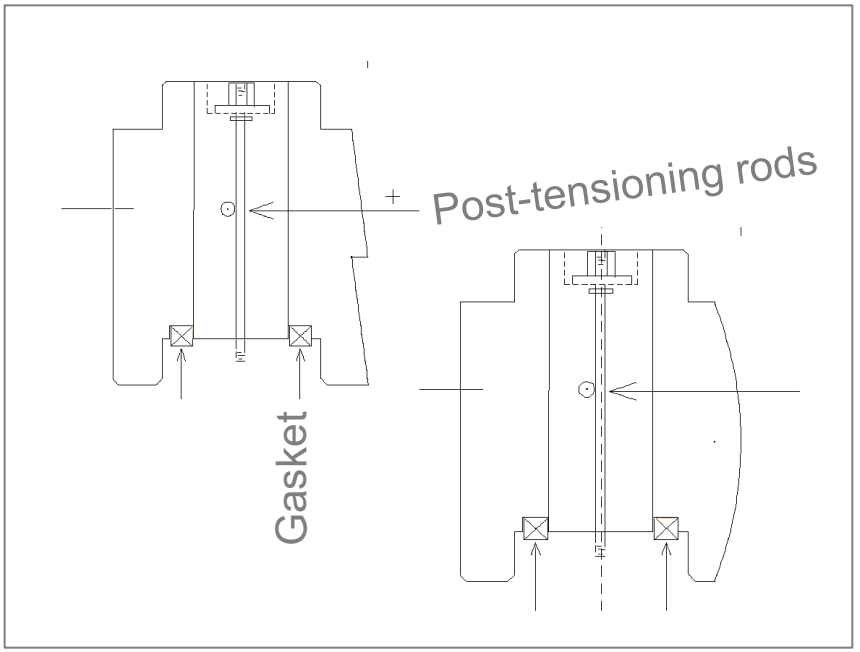
ARRO II has no full-depth thermal bridges

Pre-assembly at the University of New Hampshire Aerospace Department prior to shipping them to Antarctica

ARRO II has no full-depth thermal bridges

On site at McMurdo in Antarctica 2005

No snow inside in the spring!!!!!

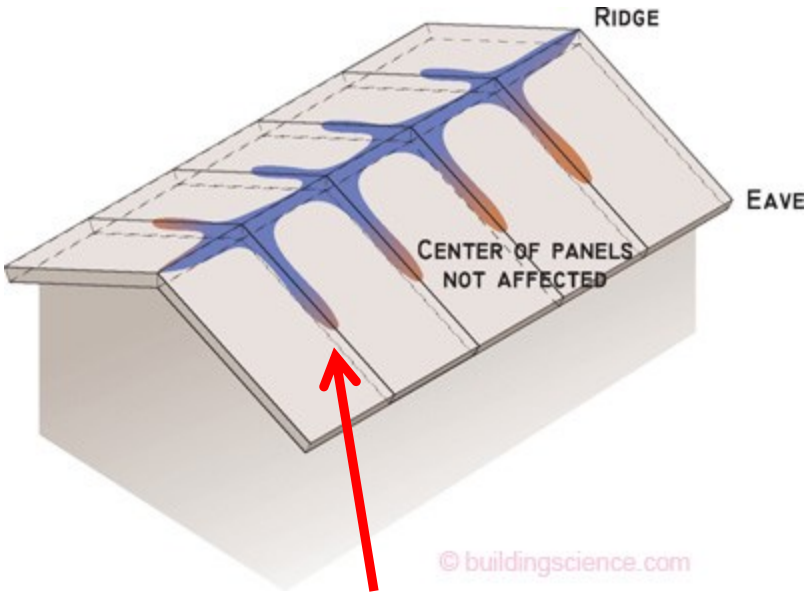


Drawing showing alternate profiles

10. The science behind the SIP failures

Building Science on Panel joints

This pattern of damage is called “ridge rot”



Note how the convection cools as it flows up the slope

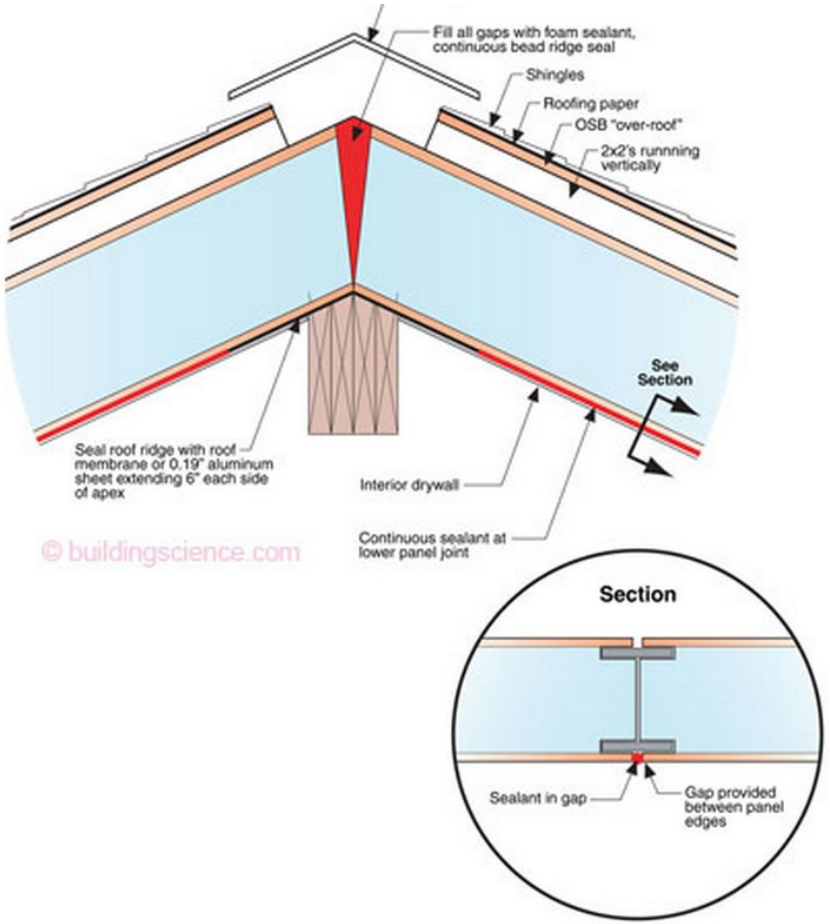


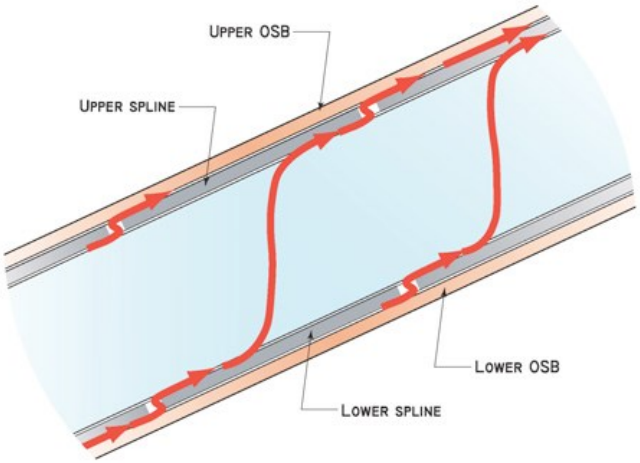
Figure 5: Avoiding SIP Roof Problems—Make the panel joints airtight especially over structural supports such as beams and purlins and provide a mechanism for moisture removal such as a vented over-roof.

Courtesy Building Science Corp

Building Science on Panel joints

Convection – internal

Note melt pattern
diagnostic method



Convection – in to out

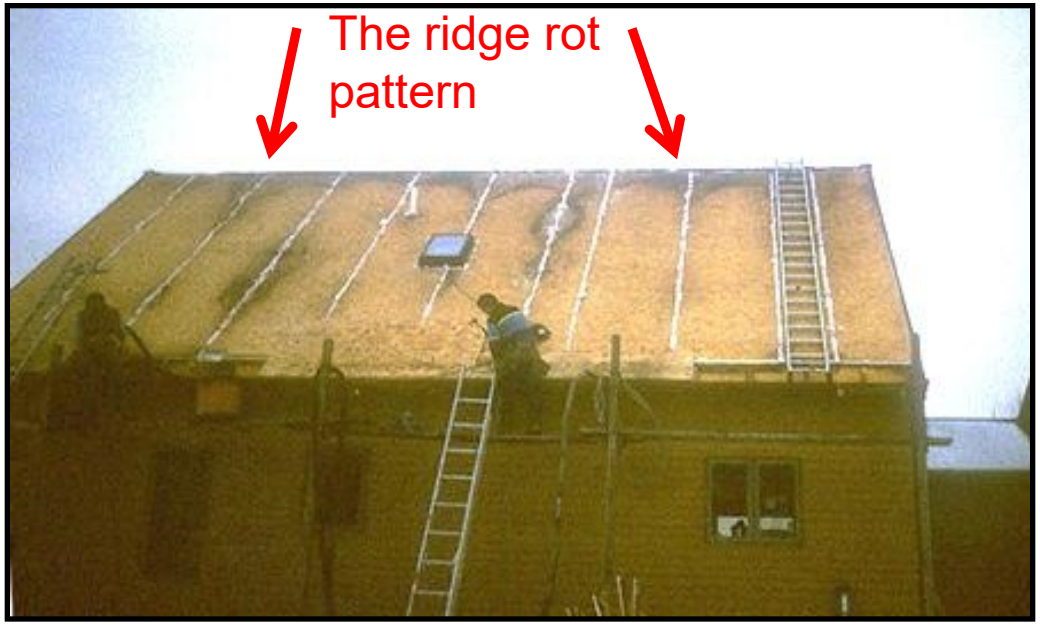
Courtesy Building Science Corp

SIP Problems

SIP problems are almost always related to sealant issues at the panel joints. Here you can see the concentration of damage along and at the top of the unsealed panel joints.

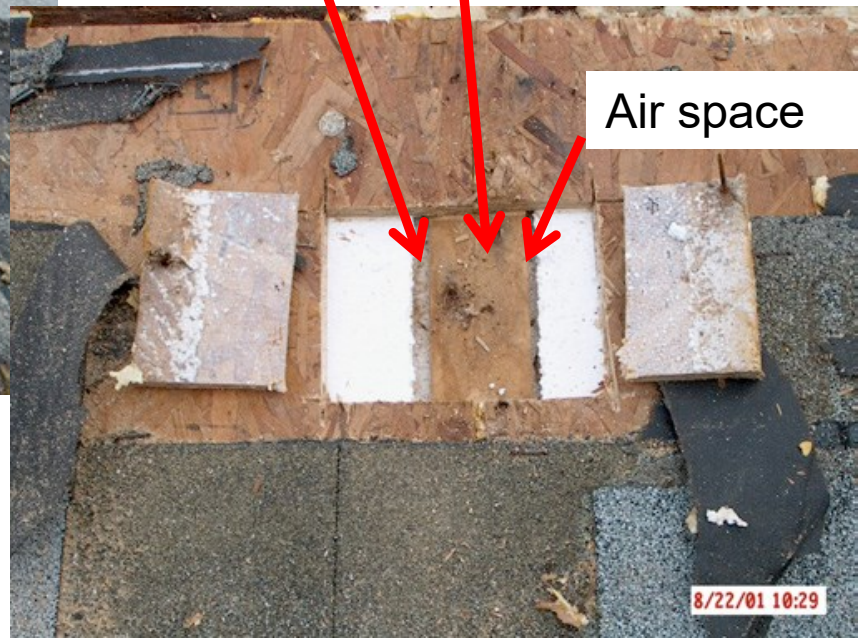
This pattern of damage is distinctive and can be found in many cold climate SIP roof failures. It can easily be avoided by sealing the panel joints by filling them full depth.

1996 repair



Ridge rot due to open panel joint

Building Science on Panel joints



The upper and lower horizontal SIP splines have air gaps along their edges creating parallel “micro-ducts”

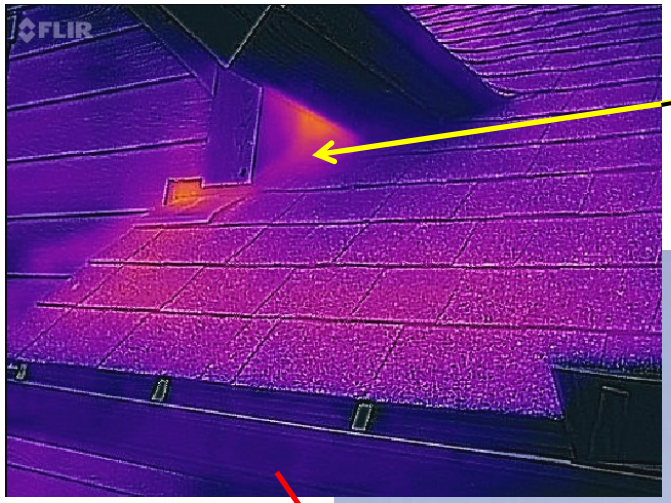
These spaces are created when routing the panel edges to create a space for the splines.

Courtesy Building Science Corp

SIP failure due to misapplied foam sealant

Lyme, NH 2017

Single-component sealant - cold chemicals without moisture



Infrared also shows air leakage

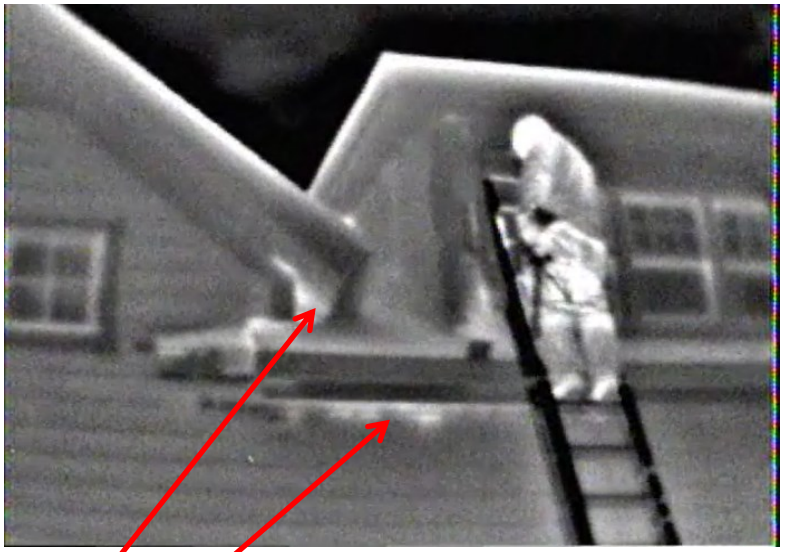
Frost due to air leakage

Lyme, NH 2017

Frost diagnosis

Lyme, NH 2017

Cold chemicals without moisture don’t perform



Infrared and daylight frost patterns –
failed panel joint air sealing

Lyme, NH 2017

Misting Instructions from Todol

“Mist the area with water before foaming excerpts

- This is our most misunderstood instruction.
- You only need an ounce of water to properly cure an entire can of foam.
- When foaming a deep void with a large cross section of foam, mist with water every two inches.
- A relative humidity rating above 55% is adequate to assure product curing.”

One-component foam sealant

Shot two Ziploc bags from the same gun at the same time on Thursday, then closed the bag on the left.

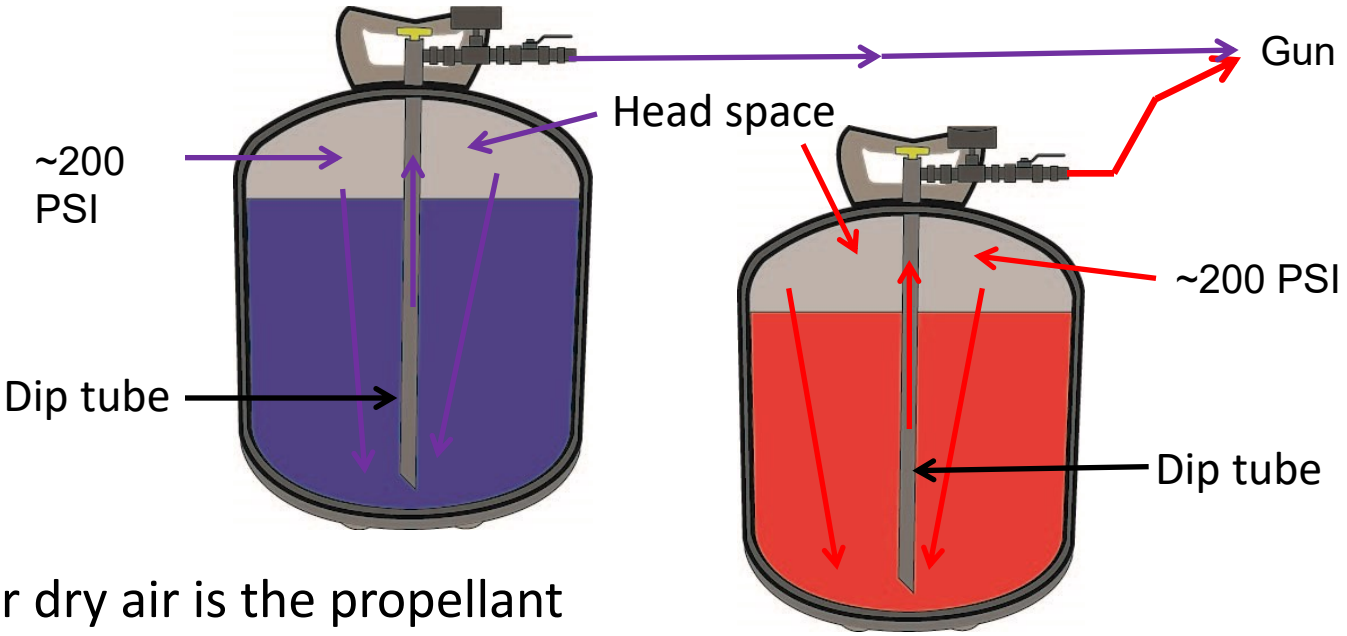
One-component foam sealant

Without moisture With moisture

By Monday, the bag on the left was just liquid!

How do kits and cans work?

Two sealed disposable one-component systems are combined to make a two-component kit

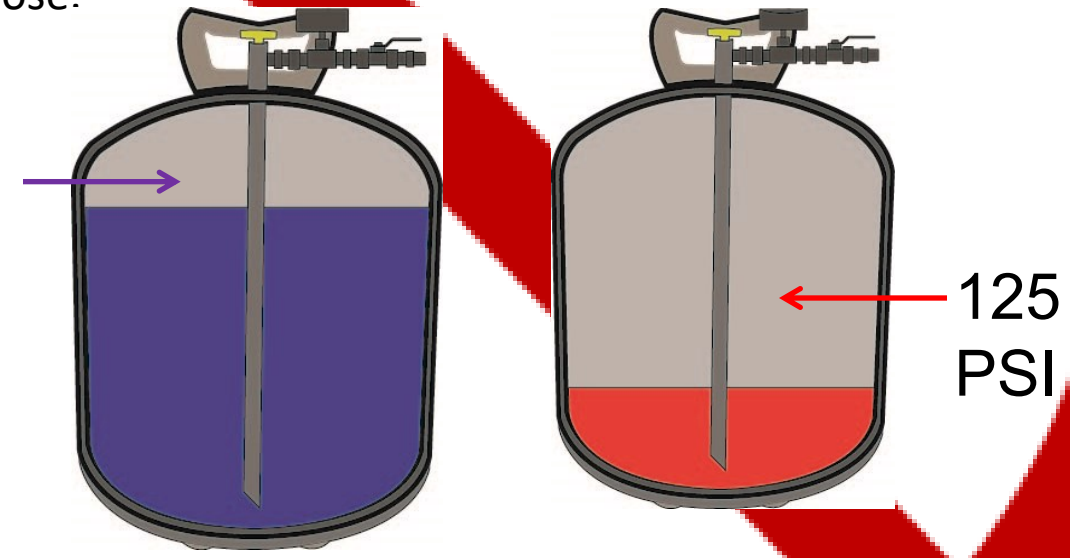


N2 or dry air is the propellant

Always keep the cylinders upright when you are making foam!

Preconditioning - Pressures

- Liquid levels need to be about the same for the pressures to be the same.
- If the levels are the same, the weights should be close.



Kits and Cans – Pre-conditioning Cans

Foam conditioning “hot box” for 200 board-foot kits (less than $100.00)

Waterbed heater

Temperature control

Water bed heater with controller ($62)

Igloo 60-Quart insulated Ice Cube Roller Cooler ($27)

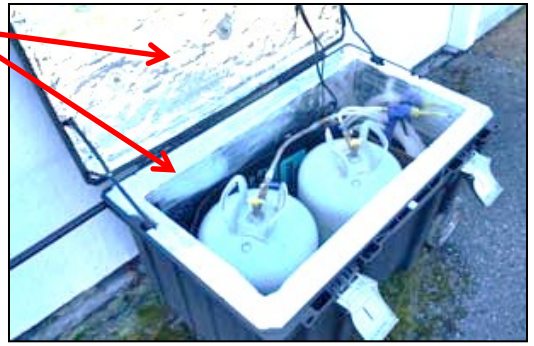
Kits and Cans – Preconditioning - Kits

Foam conditioning “hot box” for 600 board-foot kits (less than $200.00)

Waterbed Heater(s)

Temperature controller

1” sheet of Thermax and foil tape ($30)



Water bed heater with controller ($62)

Husky Roller tool box ($69)

11. Remediation – how to fix SIPs when they don't work

Remediation methods for saving the SIPs

a. Identify where the air leaks are (melt and ice dam locations, infrared, theatrical fog)
b. Create access to the leakage sites and create a joint space (the chainsaw method)
c. Fill the joint spaces “until the fog stops”with C-C foam
e. Cover the heads of the fasteners with a layer of insulation

How do you identify SIP problems

1. Testing methods for finding air leakage in SIP joints
    a. Visual inspection of open joints
    b. Infrared (with and without pressurization)
    c. Snow melt, frost, and dew patterns
    d. Pressurized theatrical fog (works year-round)
    e. Signs of ants or rot
    f. Drips that are condensation, not roof leaks
    g. Verification of flashing performance
2. Testing will help installers learn how to air seal the joints effectively

Remediation methods for saving the SIPs

1. Create a full-depth panel joint space
2. Fill the panel joint to make the seal and eliminate the convection space

Circular saw for the OSB and an electric chain saw typically with a bolt through the bar to prevent the saw from going through to the inside.

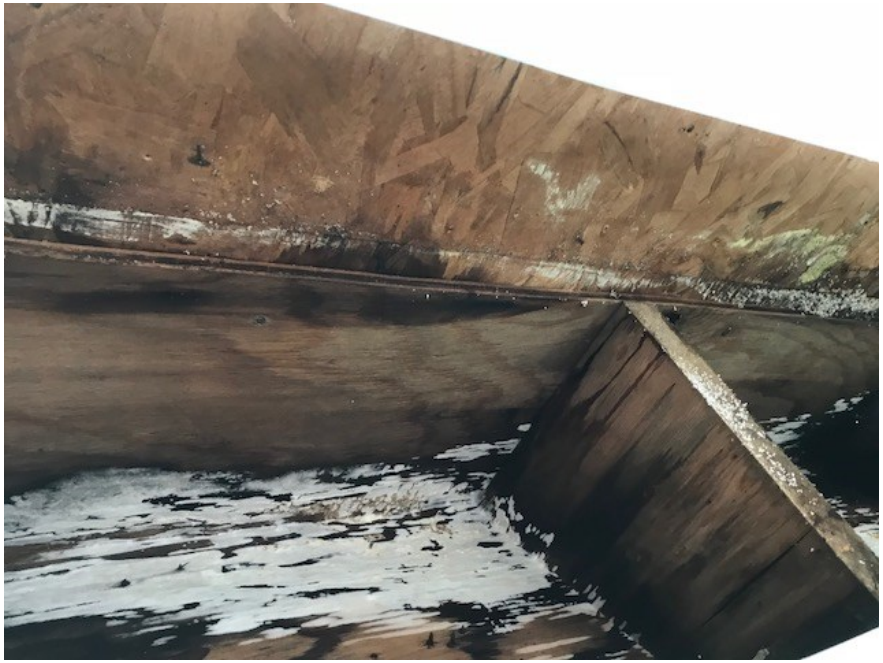
Remediation methods for saving the SIPs

Failing paint, siding, and rotted soffits indicated that there were moisture problems

SIPs installed on the frame module

6 x 6 posts on 4’ centers support
and align the SIPs without splines

Remediating SIPs



Glue-laminated
EPS SIPs

Remediating SIPs

Remediating SIPs

Remediating SIPs

The OSB has completely deteriorated over time – we called it Wheaties

Remediating SIPs

Warm air rises to the top behind the WRB

Fan penetration leaking into the joint gallery and traveling to the unsealed location

Remediating SIPs

Joints after they are cleaned out

Remediating SIPs

Mold killer coating used in areas with marginal damage

Remediating SIPs

Sealing the joints prior to gluing on the new sheathing

OSB and soffit applique are removed prior to gluing on the new sheathing and the new soffit framing

Remediating SIPs

New fasteners holding the new OSB and the original SIPs in place. The glue has to be compatible with the foam core.

Open panel joint ready to fill with full-depth foam sealant

SIP Problems

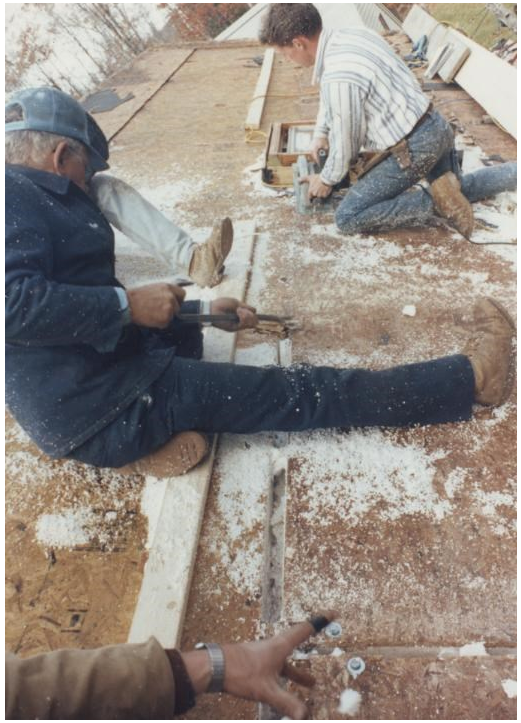
SIP problems are almost always related to sealant issues at the panel joints. In this project, ants at the ridge and along the soffits raised the alarm.

Ridge rot in SIPs

The sealant is not full depth at the vertical joints on this SIP

SIP Problems

Here the panel joints are being enlarged and cleaned out to allow full-depth air sealing. The foam beads at the interior seams verify that the panel joints were the air leakage paths that caused the moisture damage.



OSB sheathing wrinkles, heat loss, and icing over vented nailbase SIPs

Filling the vent spaces with C-C foam solves the problem

Fill the vent spaces – adds R-value and seals the panel joint air leaks

Frost-melt QA after repairs

Building Science.com Corporation

SIPs…it's about the joints and more

Thank you for your time!

QUESTIONS??

By: Henri Fennell, CSI/CDT

www.polyurethanefoamconsulting.com
Cell: 802-222-7740

COMMERCIAL FROM HERE ON

Poor air sealing can cause this damage

It is hard to tell how much of this OSB damage is from open panel joints and how much is from a flashing issue.

Poor air sealing can cause this damage

No sealant at the sill

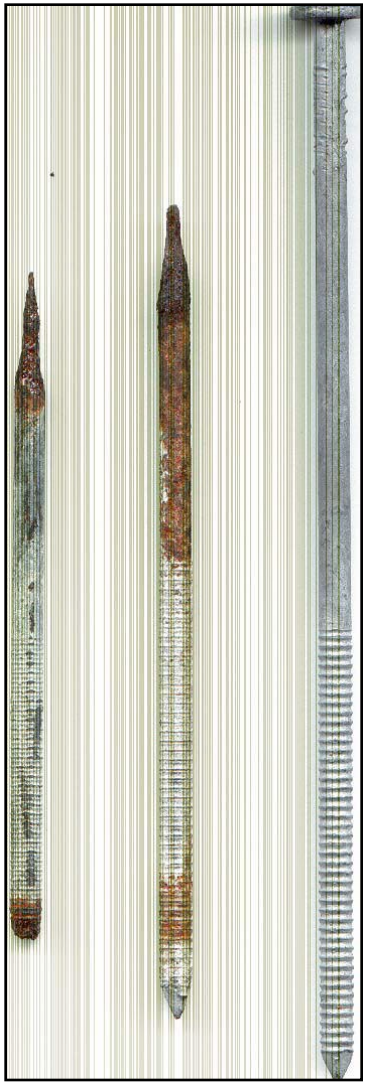
No sealant at the electrical penetrations

Panel joint failure repairs

Woodstock Resort Health and Fitness Center, 2000

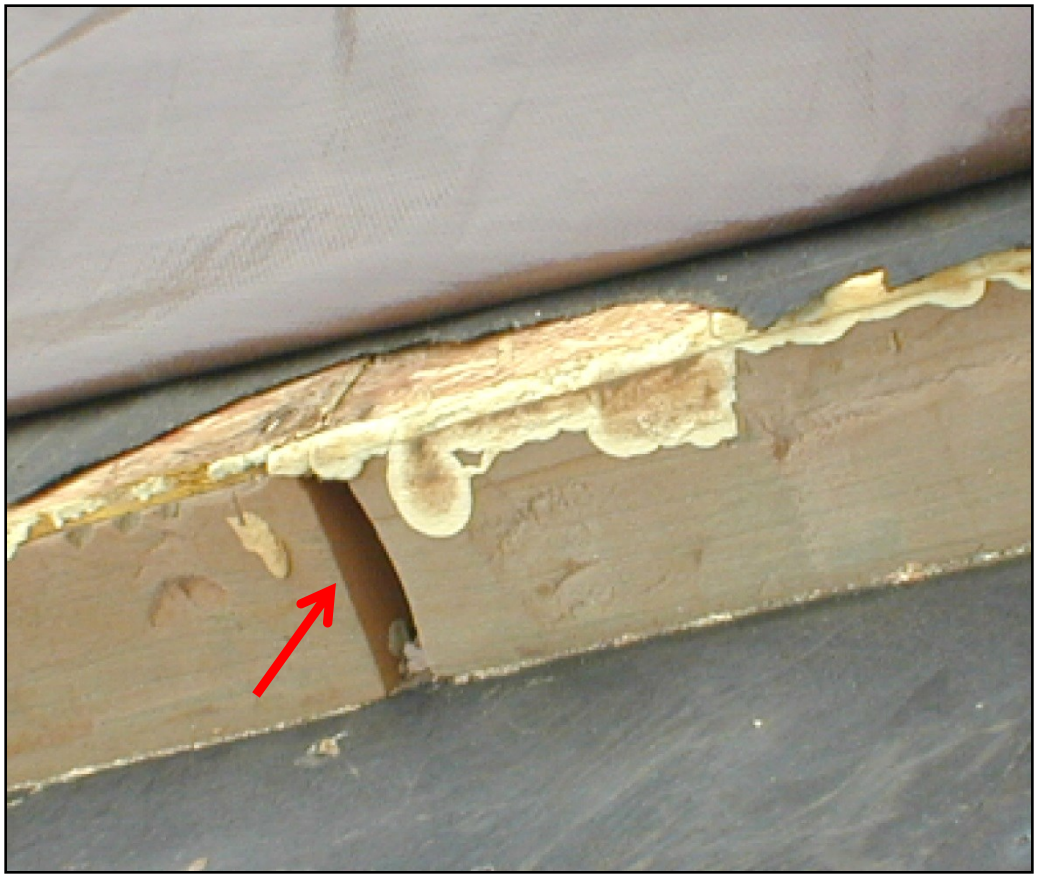
Panel joint moisture failure

Galvanized nails next to panel joint galleries corroded them completely off.

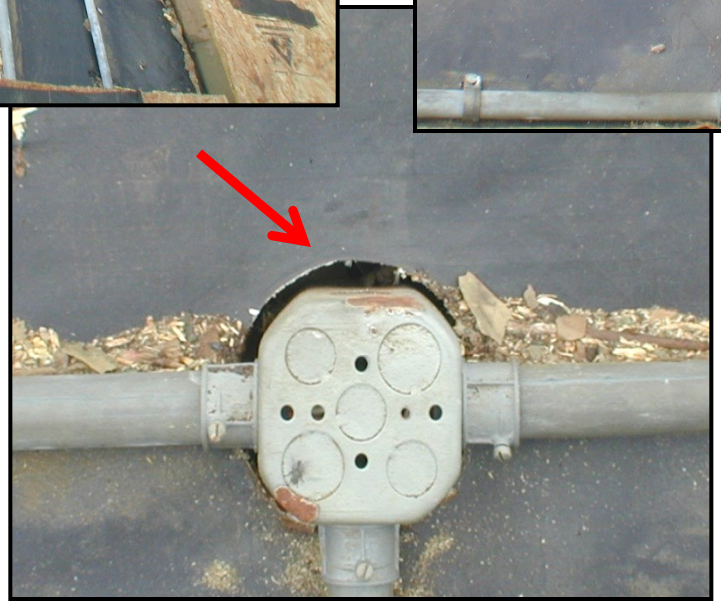


Panel joint failure – rid rot pattern

Panel joint galleries



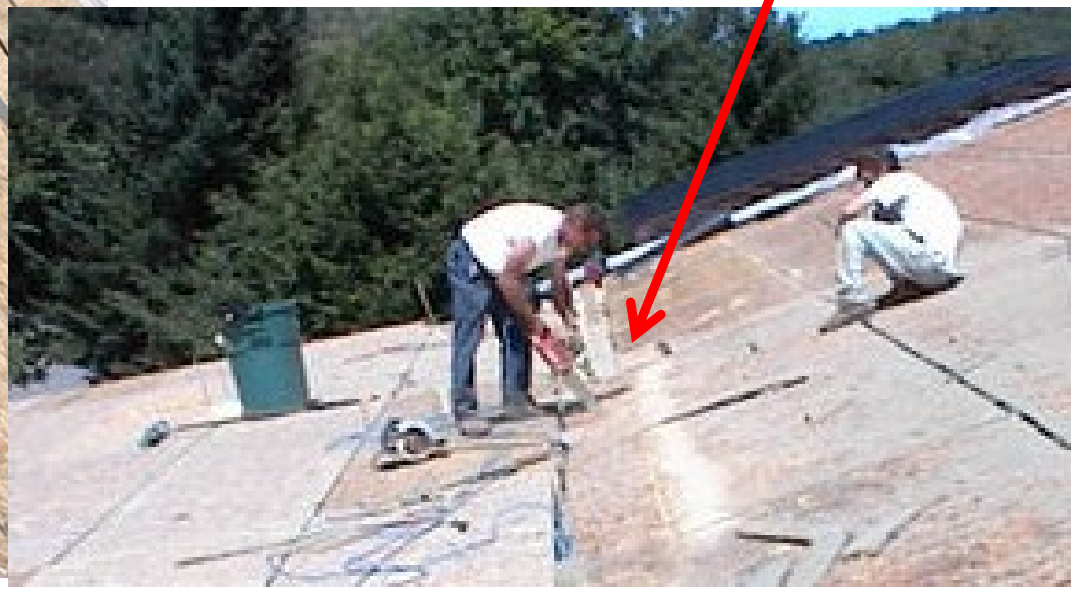
Panel joint galleries



Air/moisture from one penetration can travel throughout panel joint galleries if they are not sealed full depth

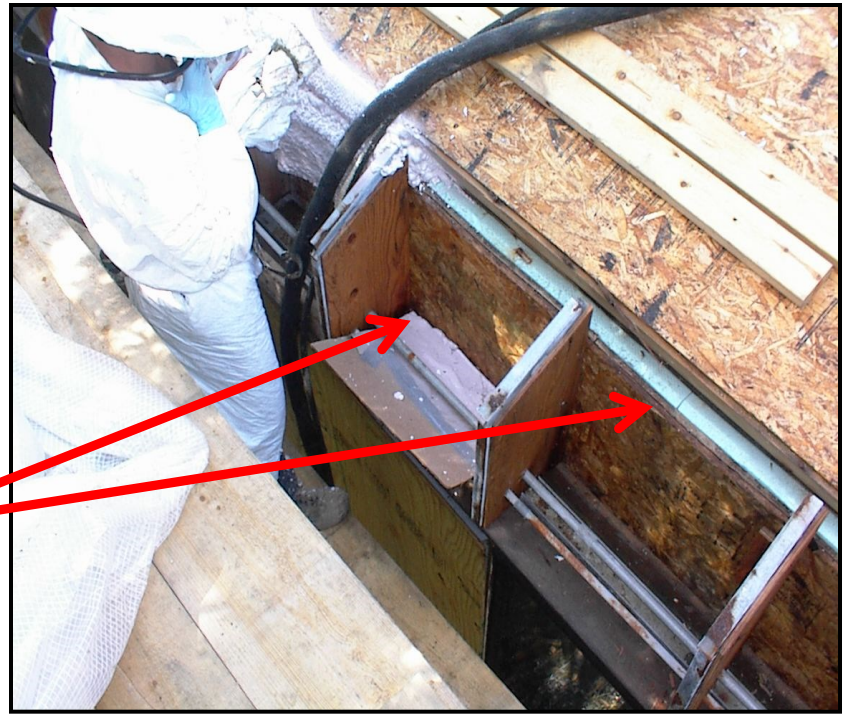
Panel joint failure repairs

Finished (chainsaw) Carpentry – creating panel joint gaps



Panel joint failure repairs

Panel joint failure repairs



Air leaks at the wall-to-roof location are open to some of the panel joint galleries.

Sealants applied during SIP installations don’t always work

IR and Fog QA methods

Expanded polystyrene and OSB SIPs installed on a steel frame in cold weather with foam sealant applied to the panel edges during the crane installation work

P.E. Energysmiths, Meriden, NH.

Vermont Law School, Royalton, VT, 1998

Finding panel joint leaks

1998

Finding panel joint leaks

Blower door setup for pressurized theatrical fog (daylight) and depressurized infrared imaging (nightime)

Finding panel joint leaks

Pressurized theatrical fog used for localized air-leakage diagnostics

Finding panel joint leaks

Note: A 10’ length of 1-1/2” PVC schedule 40 would work nicely here to support shop vac tubes and hose

Finding panel joint leaks

Finding panel joint leaks

Finding panel joint leaks

Vented roofs with compromised air barriers don’t work!

Remediating Nailbase failures

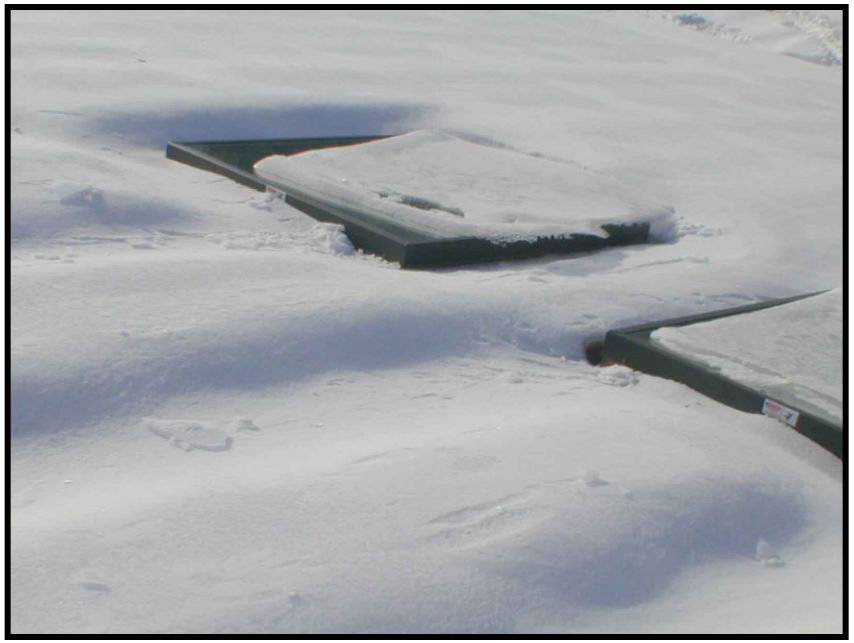
Ice dam repair, Rivendell H.S., Orford, NH, 2004

Nailbase panels on an acoustic metal deck

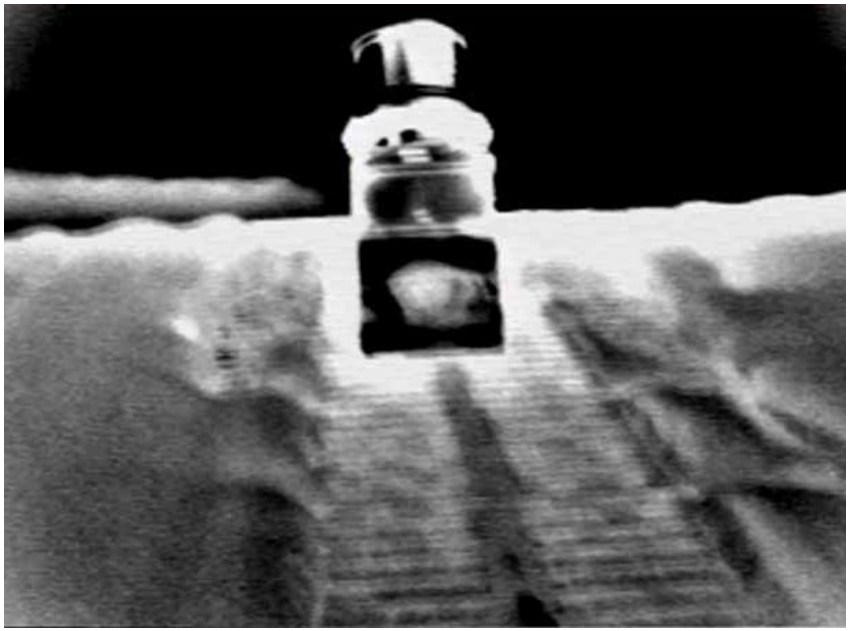
P.E. Energysmiths, Meriden, NH.

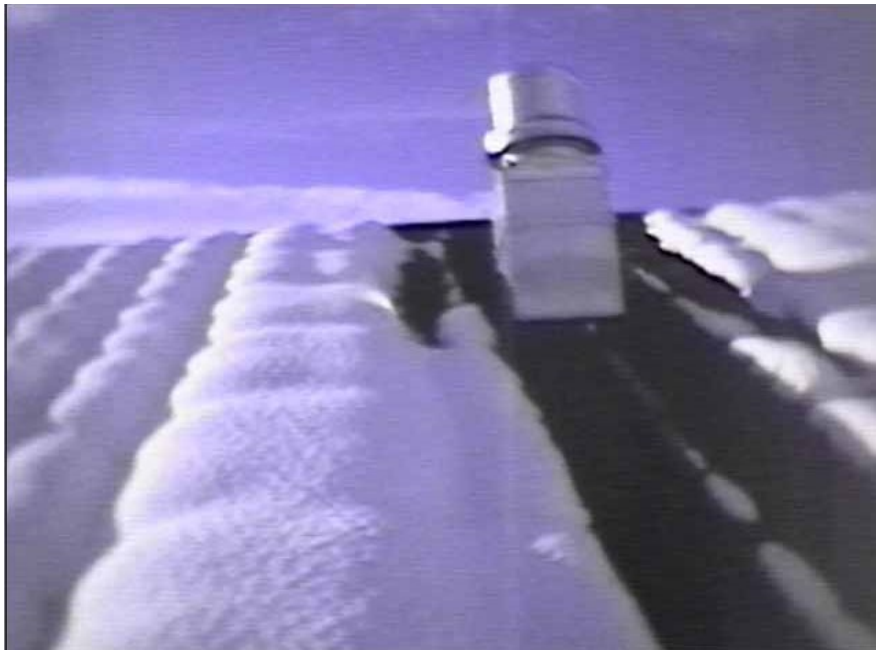
Remediating Nailbase failures

This project didn't have time to cause ridge rot, but the melt patterns show where the leakage is



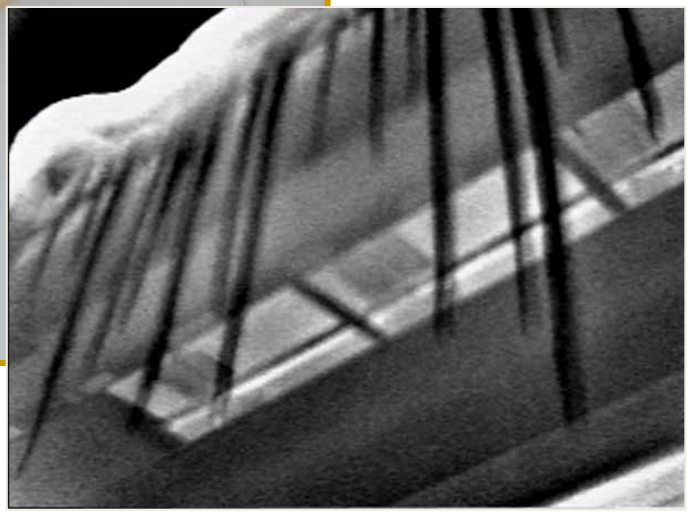
Ice Dam Remediation – Panel joint failures





P.E. Energysmiths, Meriden, NH.

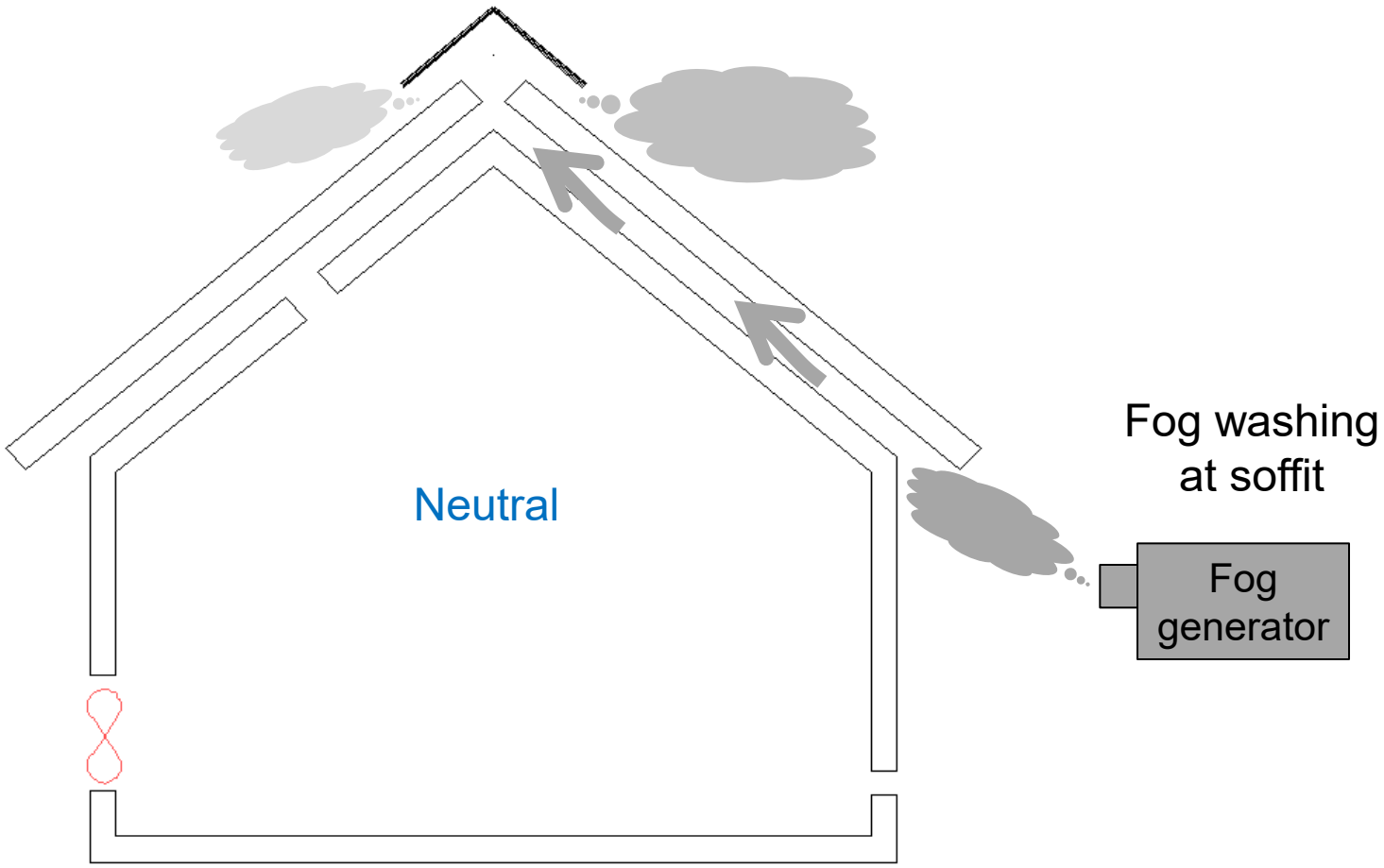
Ice Dam Remediation – Panel joint failures



Wall-to-roof transition is not air sealed creating a direct path for indoor air into the roof vent spaces

Ice Dam Remediation – Panel joint failures

Timing roof vents to verify and calculate the flow rate



Ice Dam Remediation – Panel joint failures

No roof ventilation was observed until the ridge vents were uncovered

Flow rate was timed and calculated – adequate per the design

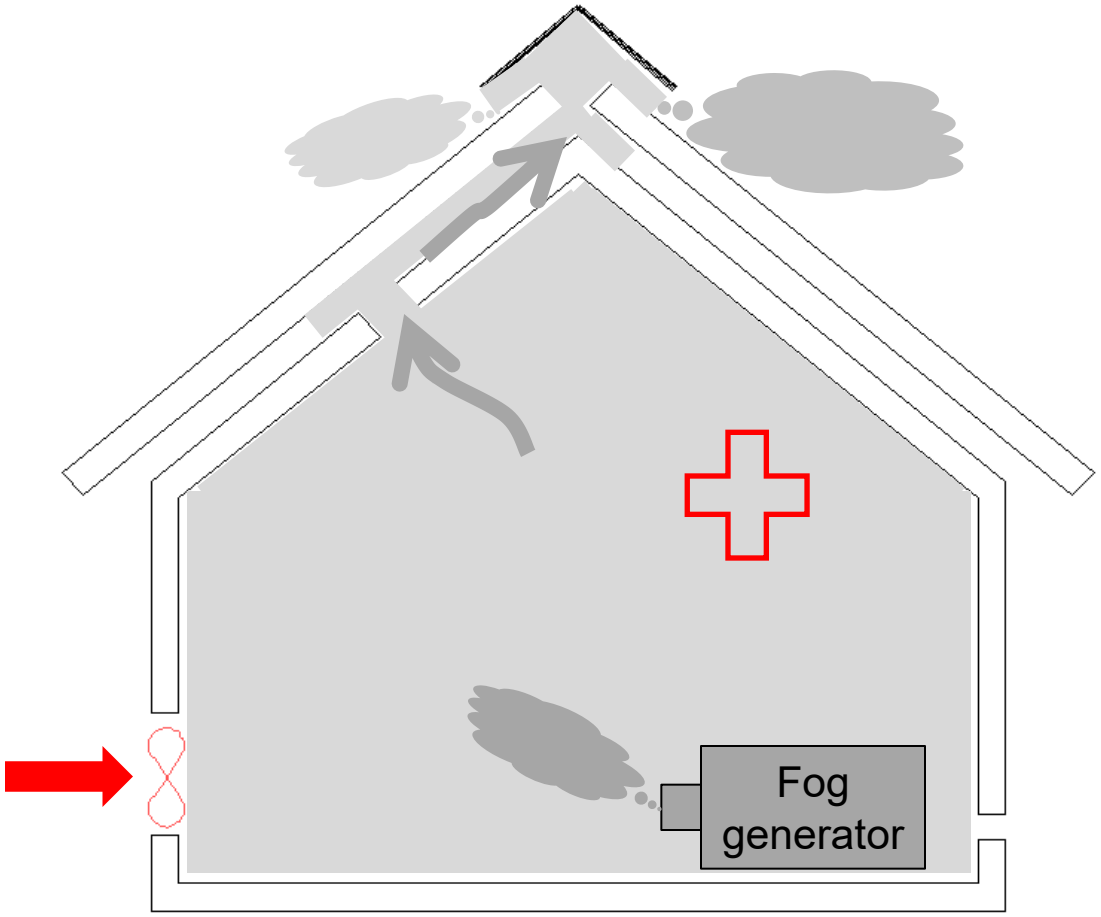
Ice Dam Remediation – Panel joint failures

Verifying that the interior is connected to the exterior through the panel joints

One classroom filled with fog and the blower window ready to pressurize the space

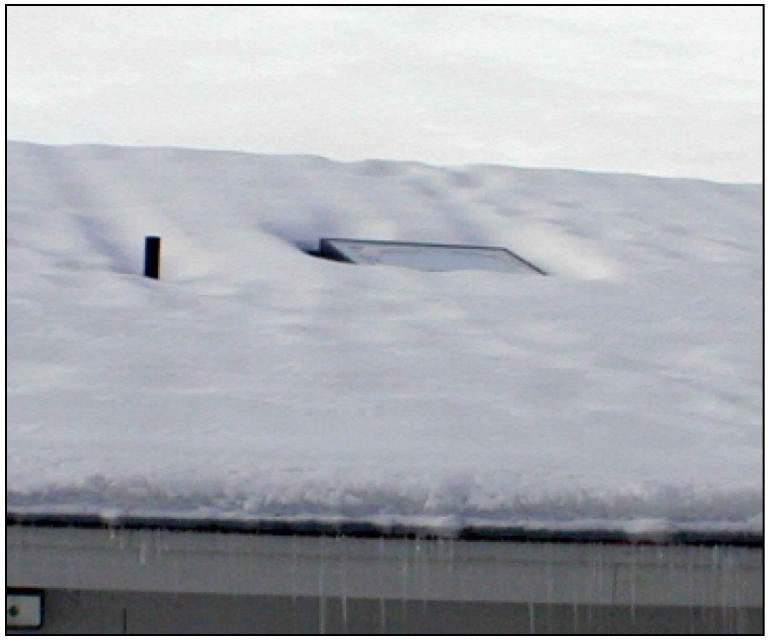
Ice Dam Remediation – Panel joint failures

Verifying that air leakage is occurring from the interior up into the roof vent space

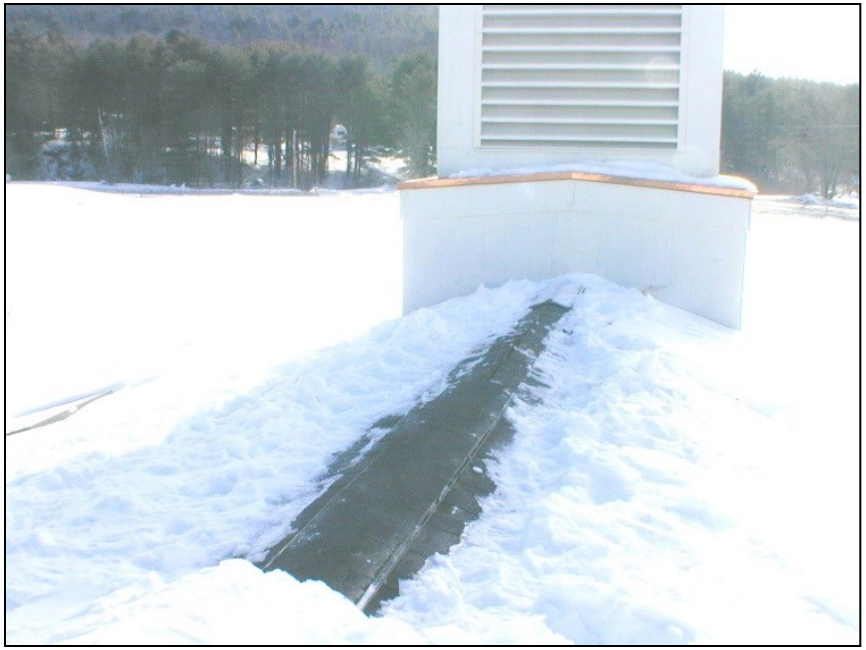


Fog leaking out at penetrations was visible at the ridge cap only after the snow was removed

Ice Dam Remediation – Panel joint failures

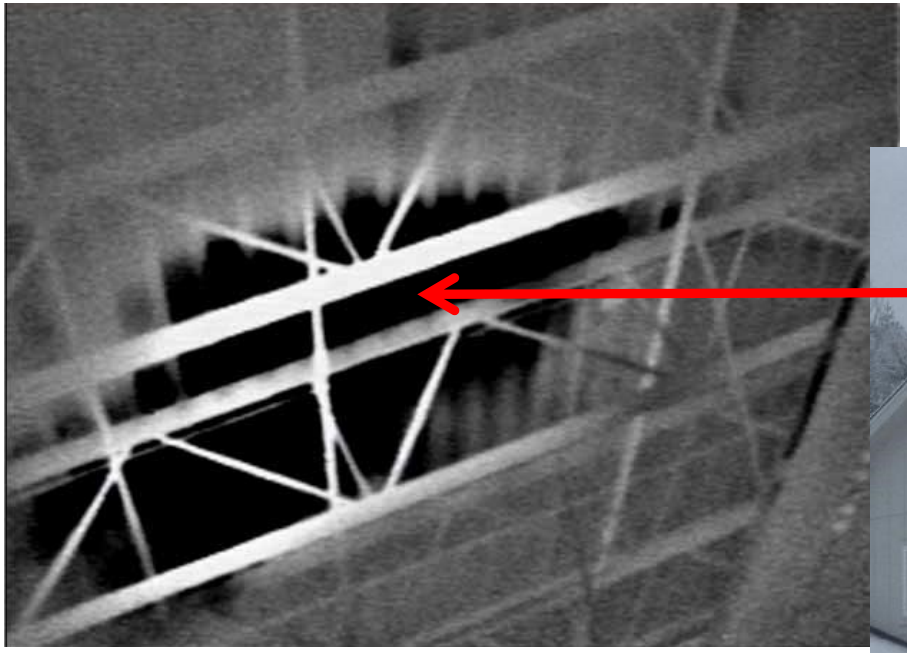


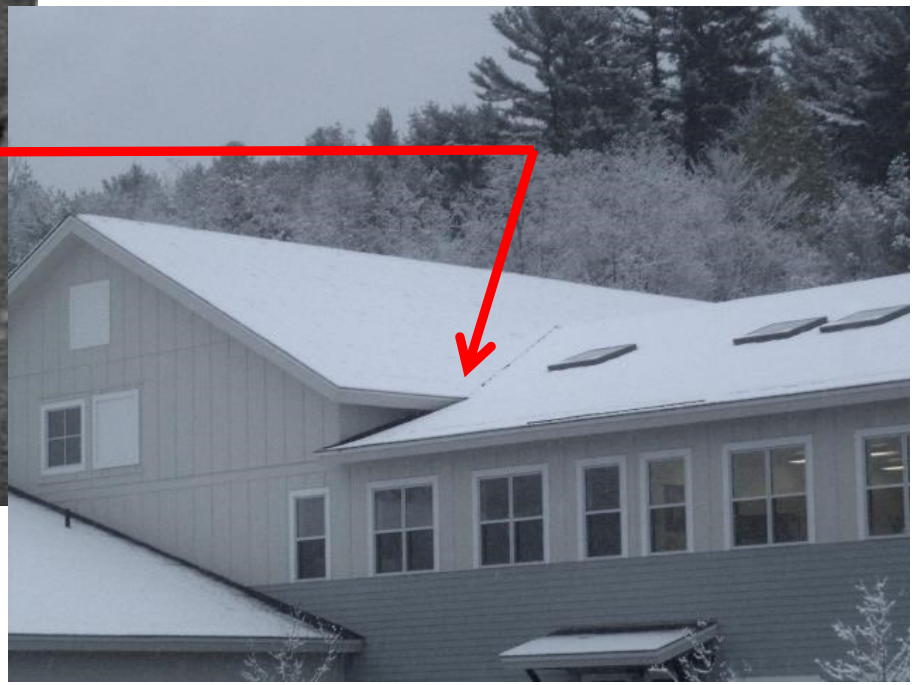
Melt patterns indicated air leakage at the penetrations and around the skylights, as well at the sofits



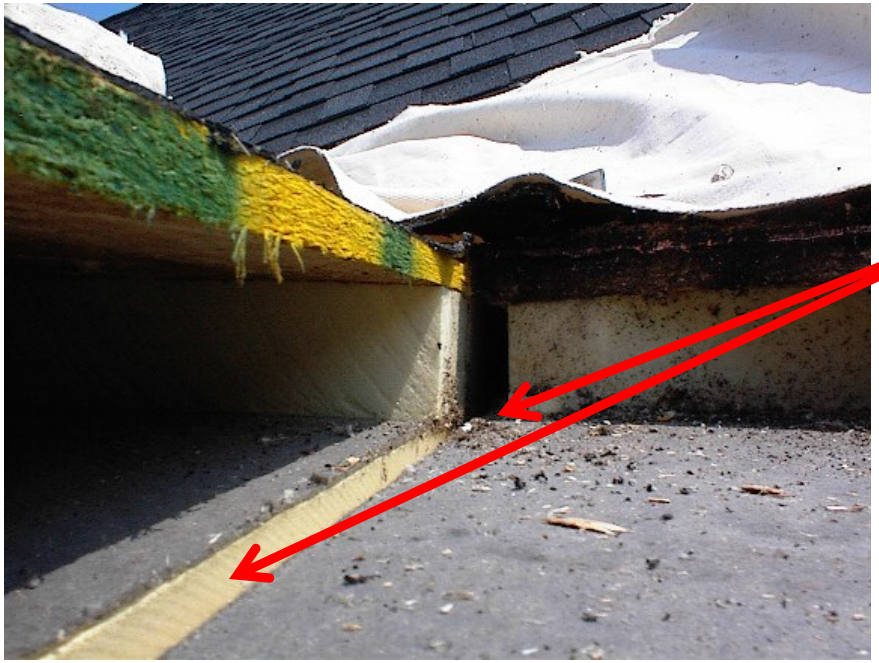
But no fog leakage was observed until the ridge vents were uncovered

Method - Depressurize the building with a blower door and use an IR camera to map out and prioritize air flow through the panel joints.





Ice Dam Remediation – Panel joint failures



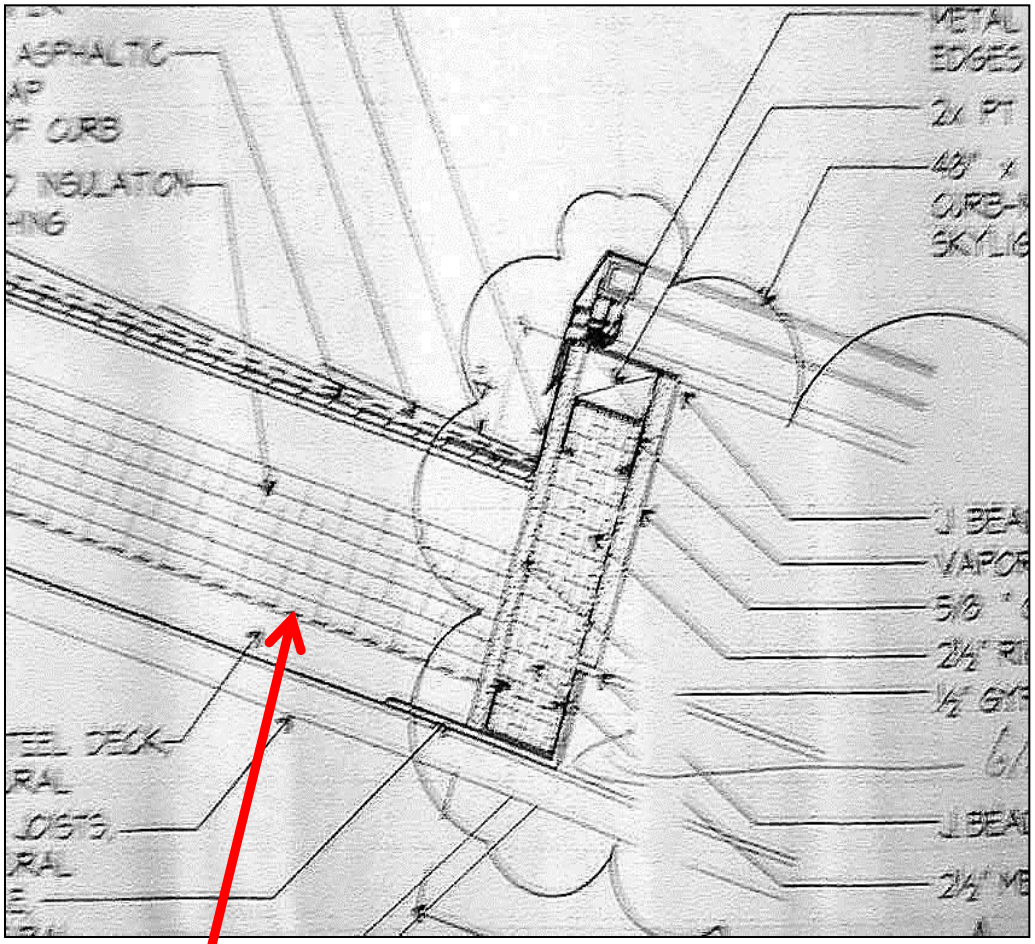
Open panel joints found at the valley condition – no sealant between the panels or in the valley gaps

Melt pattern shows that the roof vent is carrying warm indoor air up to the ridge vent from the wall-to-roof detail just above the valley.

The construction

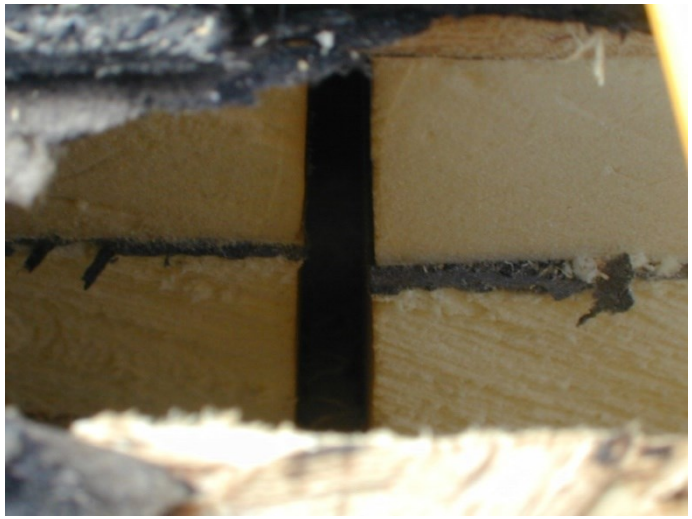
Acoustic metal deck is not an air barrier (or a foam barrier)

Skylight penetrations and air barrier



Reinforced poly was intended to be the air barrier on top of the acoustic perforated steel roof sheathing. This layer was damaged by the screw fasteners holding the nail base down.

The panel joints are not sealed



Fog test shows where the panels are not sealed to the skylight curbs

Filling the vent spaces adds R-value and seals the air leaks

Ice Dam Remediation – Panel joint failures

Rivendell School 2004 repair

Ice Dam Remediation – Panel joint failures

The panel joints were sealed and R-13 added to the roof insulation with closed-cell injected polyurethane foam

Rivendell School

Rivendell School

Overhangs – thermal bridging and solar gain

Ice Dam Remediation – Panel joint failures

Thermal bridging through the fasteners is the only melt pattern after the repairs

Remediation considerations

a. Which panel joints are failing?
b. Are the joints structural?
c. Have the fasteners failed?
d. Is the structure compromised?
e. Will the repair foam leak to the inside?

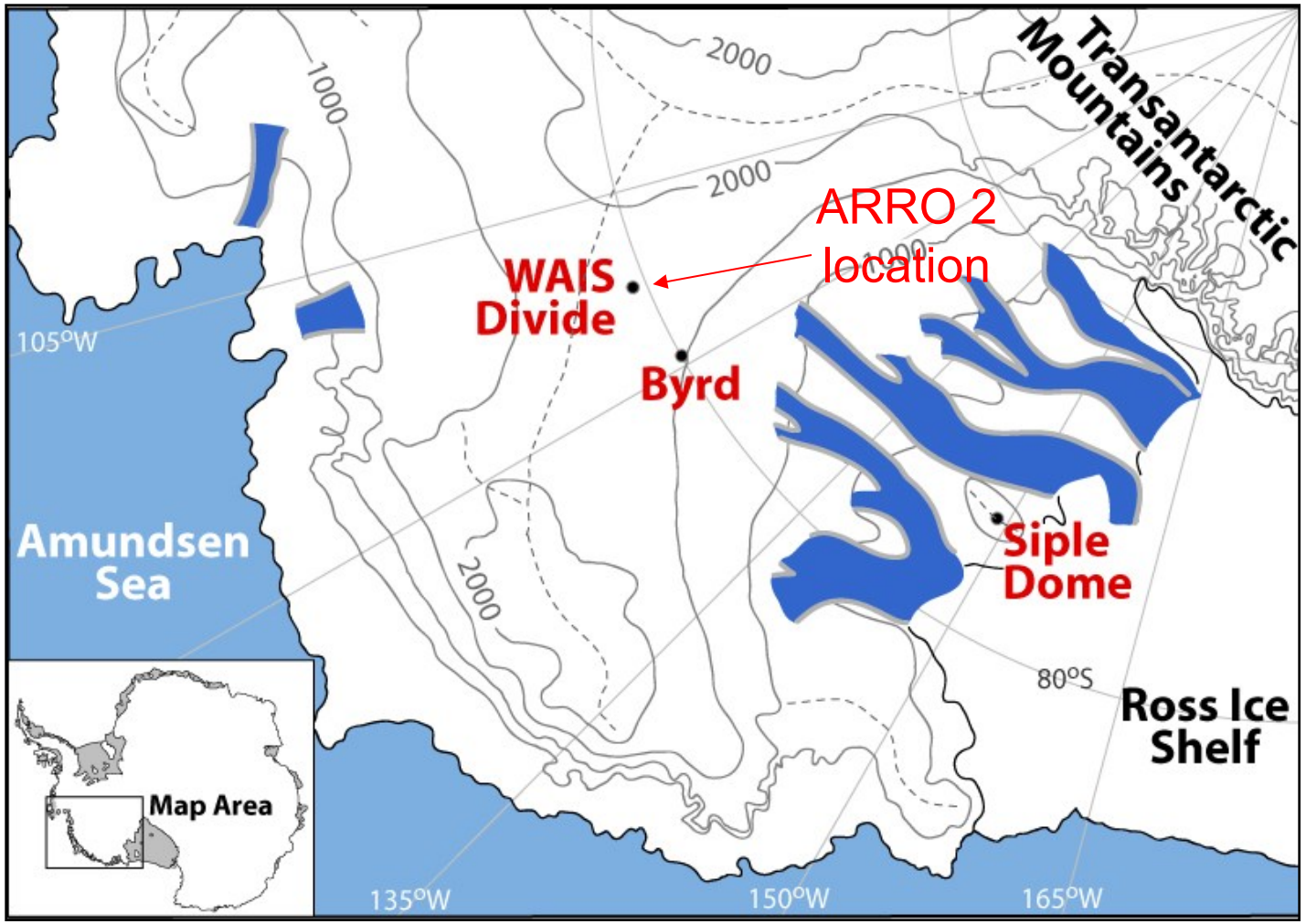
Gaskets needed!

Initial McMurdo Installation – ARRO 1

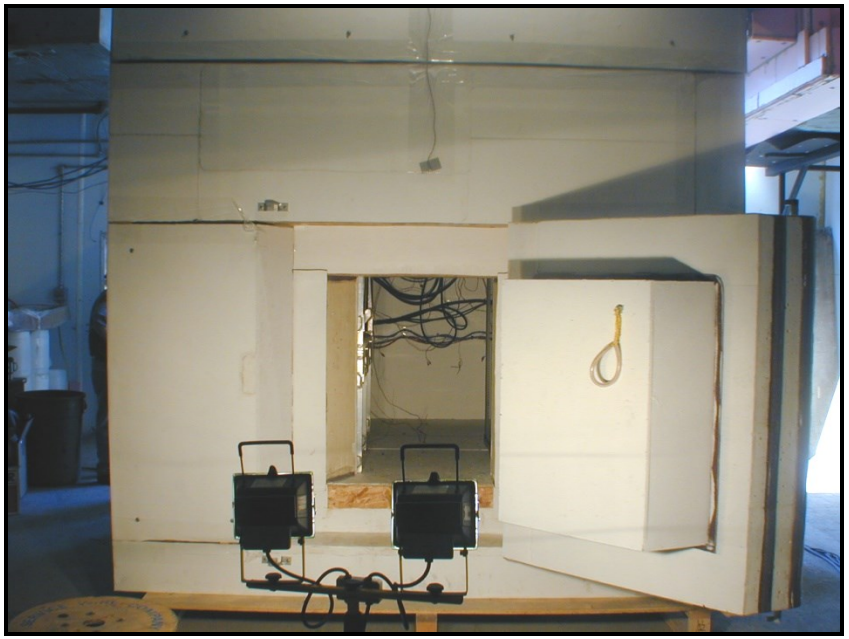
Funded in part by the National Science Foundation

University of New Hampshire

Installation – ARRO 2



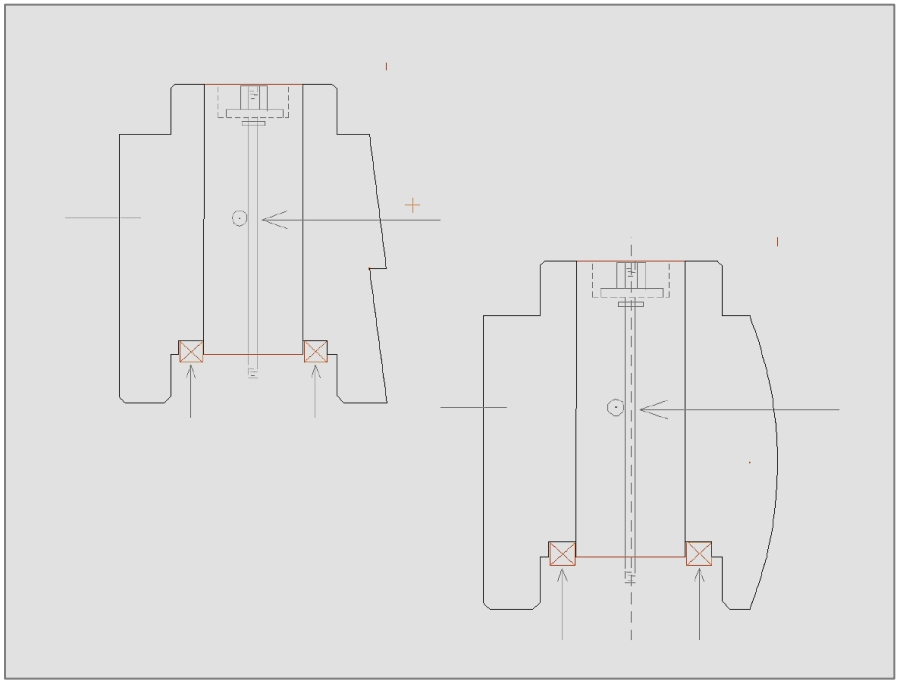
The first ARRO Project being tested at the U.S. Cold Regions Research Environmental Laboratory



~200 watts total energy for –70F outside, 70F inside.

On site at McMurdo in Antarctica

No snow inside in the spring!!!!!



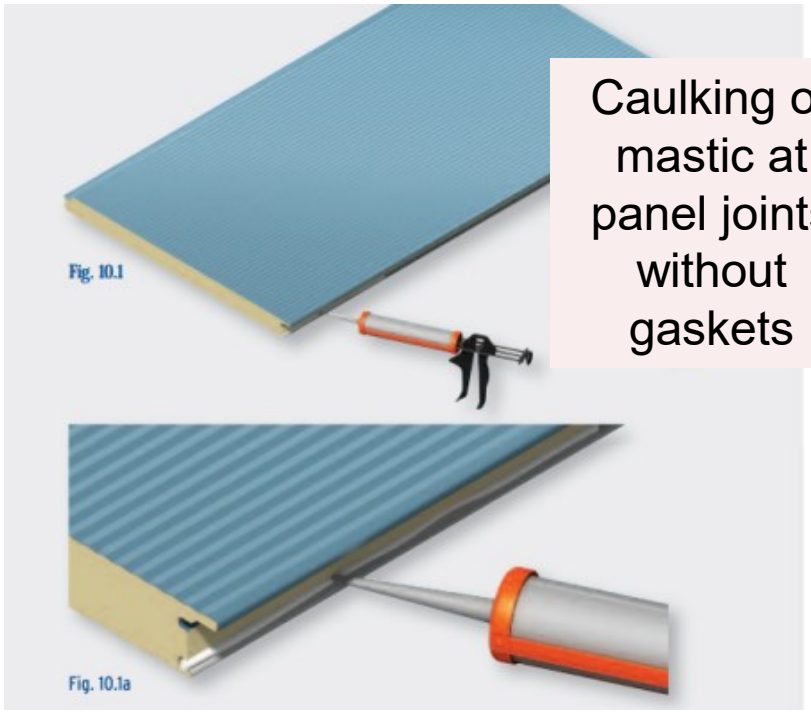
SIPs with integrated HP solar in manufactured in 1976

Locations vs. sealant types

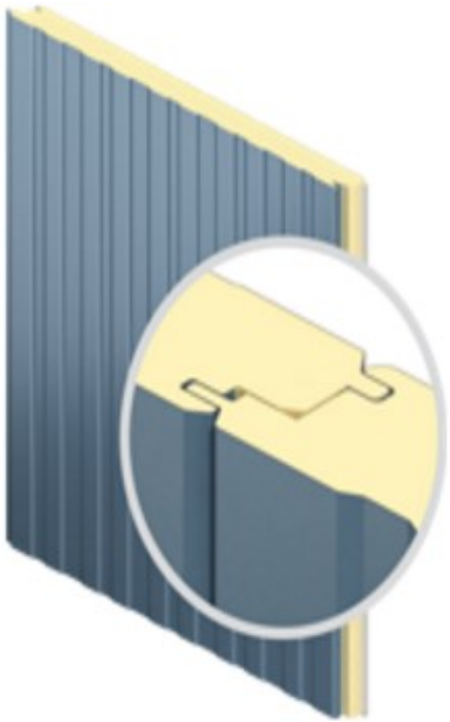
Air sealing locations	
Locations	**Sealant type**
Spline/butt joint connections	Full-thick expanding foam sealant and/or guaranteed tape
Structural shoe plate	Structural adhesive
Structural outside corners	Mastic and/or guaranteed tape
Structural inside and outside corners	Mastic and/or guaranteed tape
Structural rake connections	Mastic and/or guaranteed tape
Structural ridge connections	Mastic and/or guaranteed tape
Structural valley connections	Mastic and/or guaranteed tape
Inside and outside corners	Expanding foam sealant
Eave connections	Expanding foam sealant
Rake connections	Expanding foam sealant
Ridge connections	Expanding foam sealant
Valley connections	Expanding foam sealant
Mechanical penetrations	Expanding foam sealant
Window and door penetrations	Non-expanding foam sealant
Chimney and flue penetrations	Mineral wool and flashing with high-temperature sealant

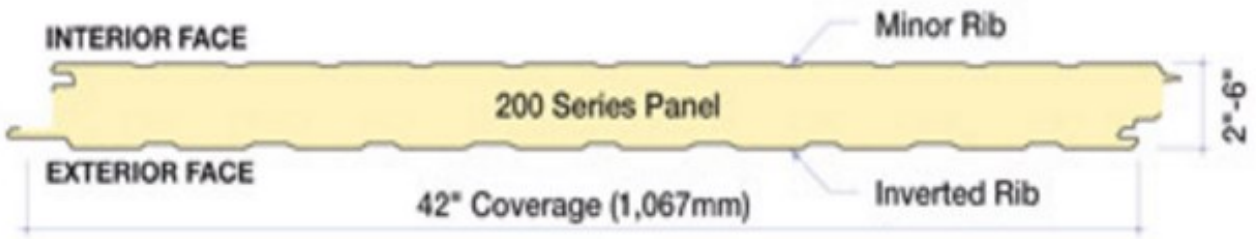
It’s all in the details

Joints between metal panels for metal buildings are typically sealed with caulk or mastic

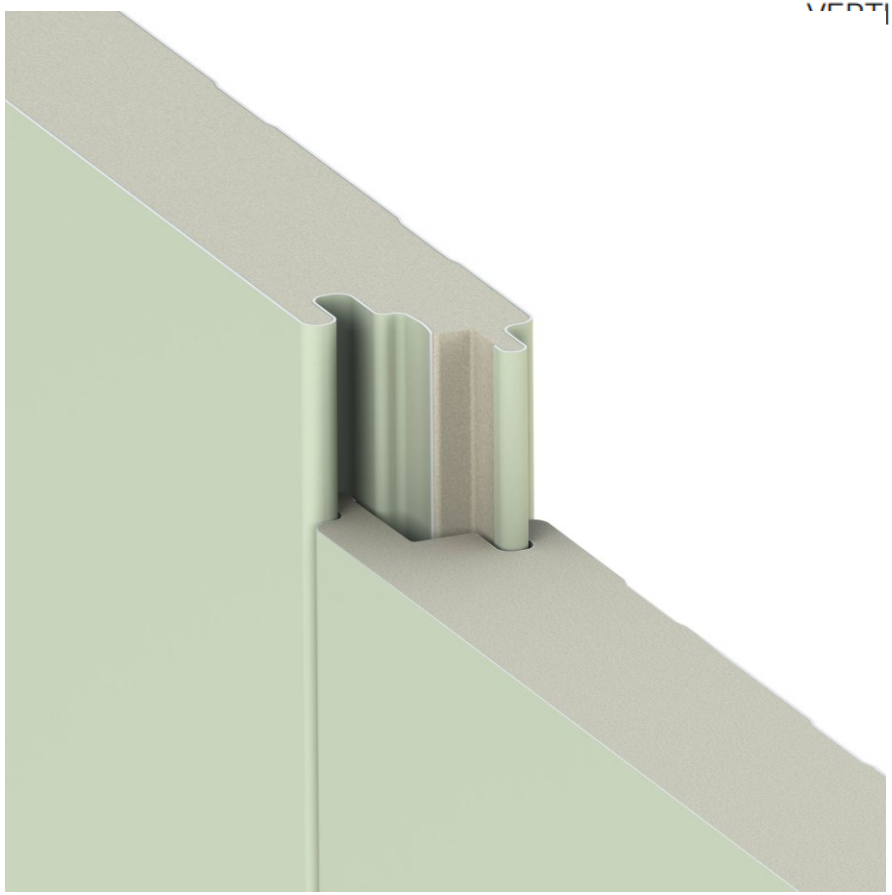


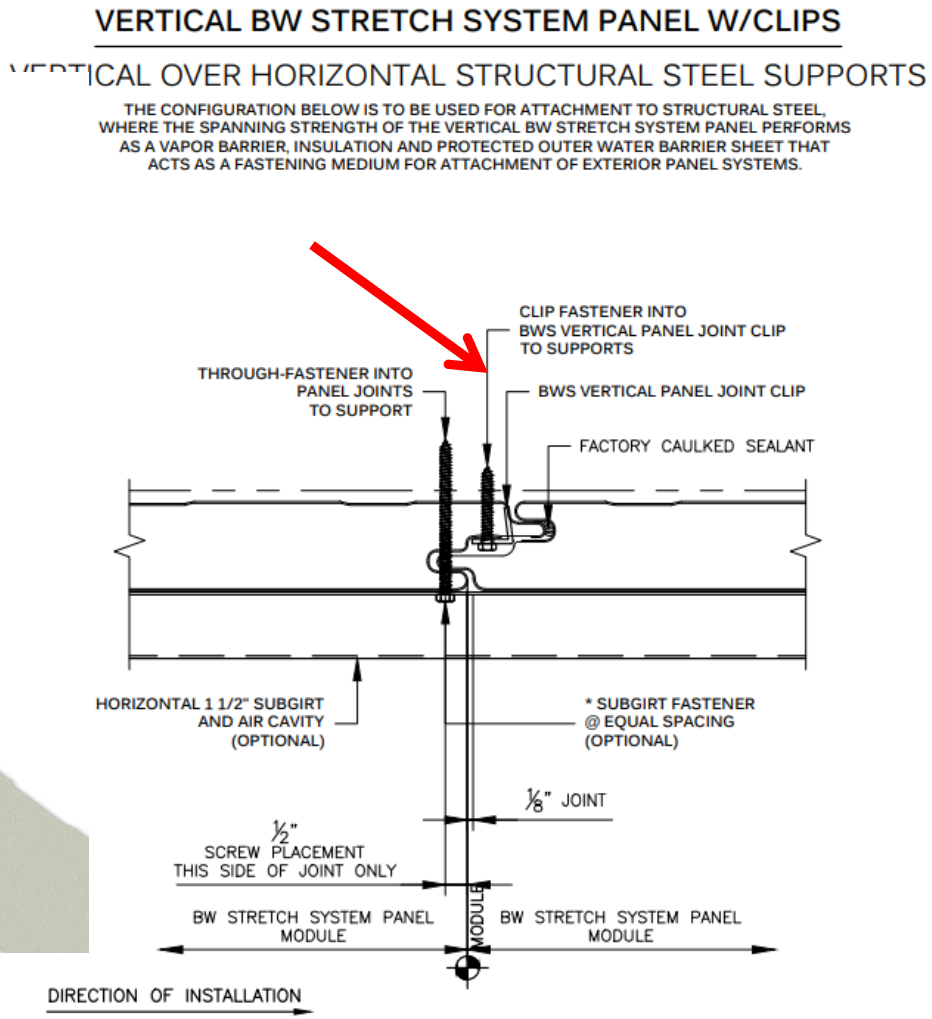
Caulking or mastic at panel joints without gaskets





Thermal break fastener detail





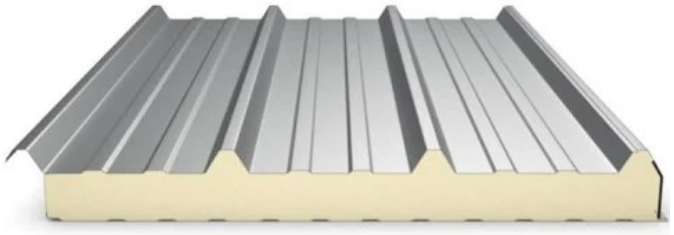
https://metlspan.com/products/wall/backup-wall/bw-stretch-system/

Special Tools for SIPs

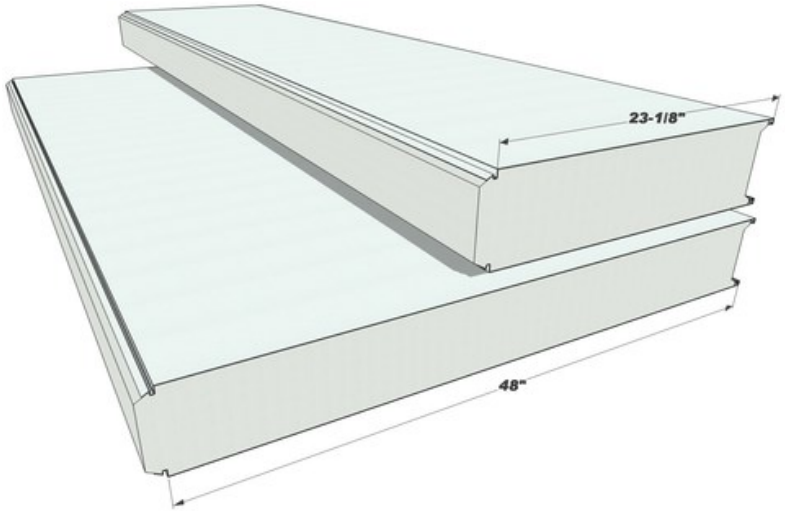
Special Tools

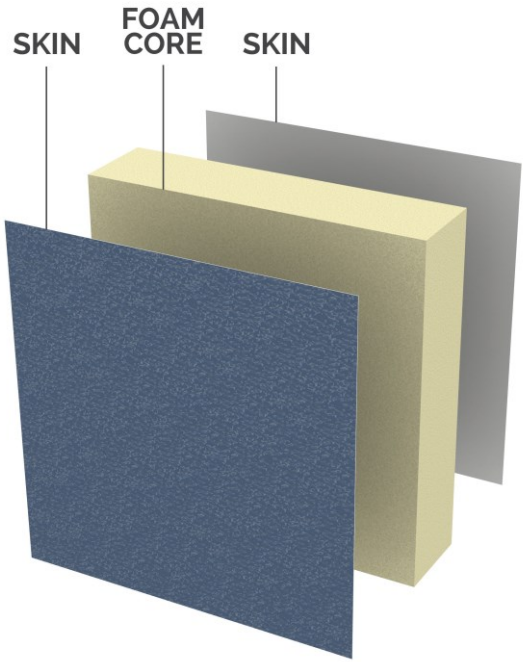
- 12” circular saw
- 3.5” panel edge router
- 3’-0” long 1” drill bit
- Fastener-specific driver
- Kit foam for panel joints
- Electric chainsaw for remediation
- Theatrical fog machine and fan for testing

SIPs – a.k.a. sandwich panels



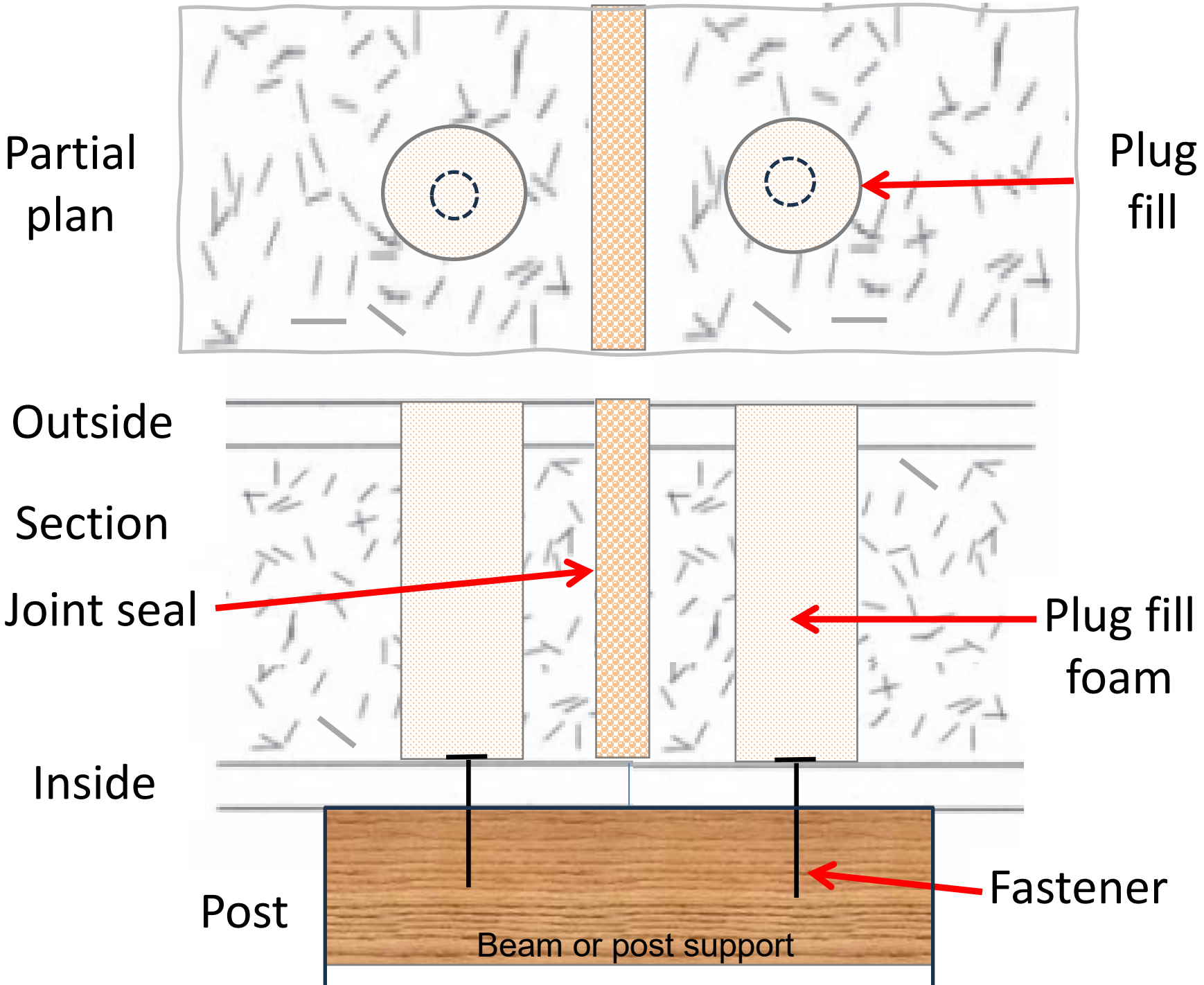
Insulated PUF steel SIPs





SIP applications

1. Timber-framed enclosures
2. Conventionally framed buildings
    a. Walls and roofs on stick-framed construction
    b. Roofs on steel-framed construction
3. Historic reversibility - Solves historical restorable considerations (New Hampshire Historical Society at 1994 - Eagle Square Masonry building). The SIP needs to be protected on the wet side.


Partial plan
Plug fill
Outside
Section
Joint seal
Plug fill foam
Inside
Post
Fastener
Beam or post support

One-component foam sealant

Without moisture

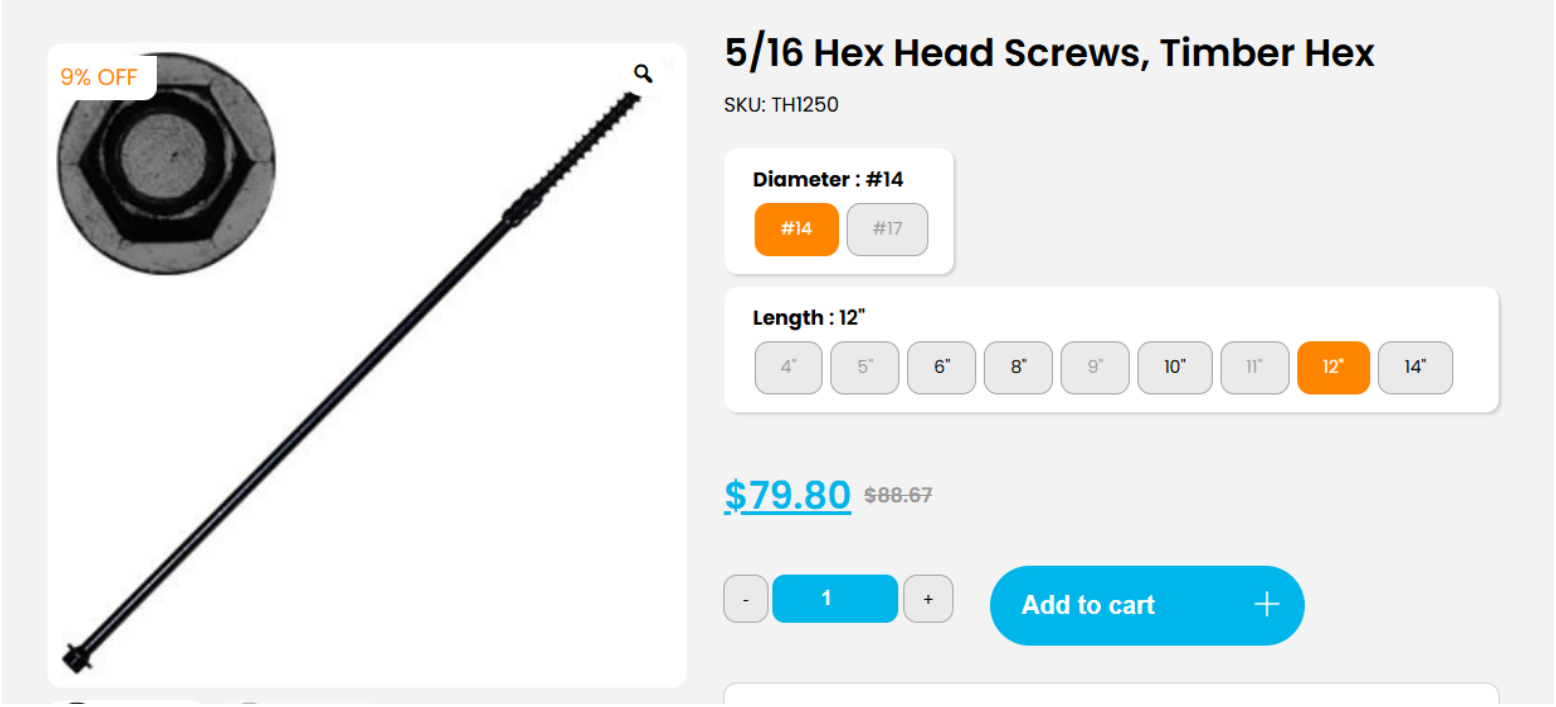
With moisture

One-component foam sealant

Without moisture

With moisture

Panel fasteners



Pole Barn Spike

Panel joint details

- The Cam Lock detail compresses the gaskets
- Often used in most cooler/freezer panels
- It doesn't work in both directions or in a change-of-plane condition
- Minimal thermal bridging
- More costly

SIPs on stick-built frame – Roof is IPF

Woodstock, VT - 1984

Custom panels for long roof spans

Long-span structural SIPs with full-thickness panel joints

York, ME - 1986