

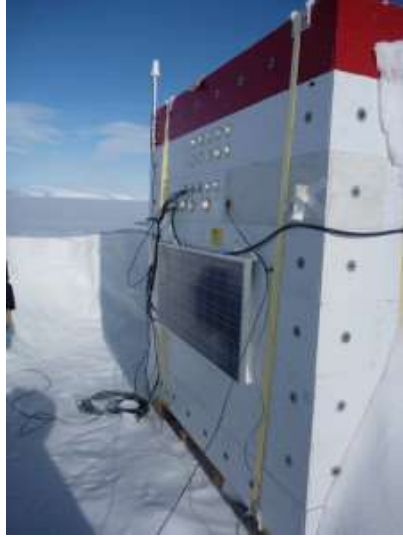
Henri Fennell, CSI/CDT

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.



The Big Dig in Boston, MA

Net-zero energy research structure in Antarctica



HCF foam experience

1. First spray foam project was in 1971
2. Foam manufacturing from 1973 to 1979
3. Foam contracting and BE consulting from 1979 to 2009
 - Developed the method for injecting closed-cell foam on site
 - Installed ~ 5 million pounds of foam
4. Foam and BE commissioning from 2009 to present
5. Noteworthy foam projects include:
 - 1977 net-zero solar project in Boston, The Big Dig, Four American Ski Grande Hotels in the Northeast, 2005 Net-zero energy weather station in Antarctica, The Guggenheim Museum
6. Two US patents and numerous technical papers related to foam & foam QA



Copyright Materials

This presentation and the related handout material is protected by US and International Copyright laws. Reproduction, distribution, display and use of the presentation and the related handout material without written permission of the speakers is prohibited.

© HC Fennell Consulting, LLC 2023

The Depressurized Interstitial Space SPF Remediation Method

Maine IAQ and Energy 2023

October 30, 2023 | Portland, ME

Presented by: Henri Fennell, CSI/CDT

H C Fennell Consulting, LLC

October 30, 2023

What is the problem this program is addressing

1. Remediating SPF off gassing in a cost-effective, safe manner
2. What is SPF off gassing during a standard installation?
 - During the spray application, chemicals are atomized in the work zone
 - During the exothermic chemical reaction, vapors are released
 - After the reaction and cure are complete, the product is typically inert
3. What causes long-term SPF off gassing?
 - Misapplied SPF can continue to off gas – this is rare, but my job is to plan the remediation of these projects
4. How is SPF off gassing verified?
 - Air quality and bulk foam off gas testing can determine that there is off gassing and that SPF is the likely source
 - Medical verification can also be used for occupants with unusual sensitivities

The two methods we will discuss for remediating misapplied foam

- Remove and replace
- Isolate and depressurize the interstitial space (for finished spaces)
- This method is for places where you can't just ventilate an entire isolated space (Attic, crawl space, etc.)



Bathroom fan installed in a large open attic to maintain a negative pressure



The two methods we will discuss for remediating misapplied foam

The typical consultant recommendation is “remove and replace” any SPF.

- Other consultants think it is the only guaranteed solution.
- In fact, residue can remain in the structure after the foam removal, which is never 100%. Some require removing the substrates as well, which makes remediation very expensive and unlikely to occur.
- Replacement materials can also create a new/different IAQ issue.

What does remove and replace require

1. Move the occupants out – rent a temporary home and storage for their belongings
2. Remove the interior finishes
3. Remove the foam – repair the damaged mechanical systems
4. Neutralize and seal the substrate materials
5. Test the air to verify that the home is safe after removing the foam
6. Replace the foam insulation
7. Test the air to verify that the home is safe before covering the foam
8. Replace the interior finishes
9. Move the furniture back into the home
10. Move the occupants back in

IAQ verification

To be clear, three indoor air quality tests would be performed with the remove and replace method.

Once to verify that there was a problem, once after removal to hold the replacement foam installer harmless in the event of a second problem, and once after the replacement to assure the Owner that the problem has been solved and the air is safe.

Removal and replacement



Removal and replacement



Removal and replacement

- These are really hard, and they go down 5'.



Removal and replacement




After removal

- Obvious residue left on/in the substrates
- If inside, this would have to be neutralized.
- Agree in advance how much is enough!



Diagnosis

- Metal detectors don't work on plastic piping. They do help for wiring, copper plumbing, and cast iron drains.
- This water line was cut. 



The remediation process - removal

Flat bar and a hammer worked the best

Fortunately, this material has access from the outside, so PPE and ventilation was not always required.



The remediation process - removal

Three days for two men – approx. 120 sq. ft. No wires cut, one water leak found.



Removal and replacement

Removal remediation methods

- Rim joists and complicated framing areas can be virtually impossible.
- IAQ protocols must be maintained during removal.
- Mechanicals are almost always damaged.
- Disposal can be expensive.
- PPE and ventilation are required for the workers.
- IAQ testing after removal is still required to verify that there is no dangerous residue in the substrates.



The two methods we will discuss for remediating misapplied foam?

The Alternate Method - Isolate and depressurize the interstitial space

- This is similar to the standard radon gas method of remediation
 - Common radon systems depressurize the soil/gravel under the basement and/or crawl space slab and exhaust the vapors outside of the home
 - Common radon systems are a proven technology and use well-developed equipment
 - Common radon systems use very little energy

What does the alternate method do?

1. Prevents toxic vapors from entering the occupied space until the off-gassing stops - without removing and replacing the insulation system.
2. The purpose of depressurization – maintain a negative pressure with respect to the occupied space in the interstitial space (outside of the occupied space).
 - Reduces the required ventilation rate/cost vs continuously ventilating the entire living space.
 - Reduces fan noise
3. Lab tests post-remediation can:
 - Give the Owners confidence that the air quality is safe – OK to move back in if they have evacuated.
 - Be used to fine tune the fan flow rate.
 - Serve as certification of safe indoor air quality when selling the property.

The two methods we will discuss for remediating misapplied foam

The Alternate Method - Isolate and depressurize the interstitial space

- What is an interstitial space in this application?
- The existing space between the SPF and the interior finishes

What are the details of the alternate method?

1. Purpose of isolation – separate the occupants from the off gas vapors
2. What is the isolation boundary – walls, floors, ducts, drywall between the occupied space and the foam.
3. Physical boundaries have leaks (Electrical outlets, Recessed lights, Window trim, Baseboards, Chases for chimneys, plumbing, and ductwork – open-top partitions).
 - Air handlers and ductwork can move foam vapors around if they are not perfectly sealed.
 - The depressurization fan should be as small (low flow rate) as possible, but adequate to overcome the combined boundary leaks.
 - The depressurization fan should be as small as possible to reduce energy waste (minimize replacing conditioned air) over time.

The two methods we will discuss for remediating misapplied foam

1. This method requires that the foam is of adequate quality to work as insulation, in spite of its off gassing.
 - Most misapplied foam is usually of serviceable quality as insulation even if it is off gassing.
 - Its performance (R-value) may be somewhat less than properly installed foam, but it is usually cost effective to salvage it rather than removing and replacing it.
 - I usually see the costs of this type of remediation that are 1/10th of the cost of remove and replace.
2. All of the interstitial spaces must all be connected to an exhaust fan. This may require built-in manifolds and multiple fans in complex locations. Still much less expensive than remove and replace.

What are the details of the alternate method?

3. Equipment

- Fans
 - Purpose of the fan(s) – Remove the vapors
 - Types of fans – radon fans are well suited to this application
 - Single-speed vs. variable speed fans – variable speed fans will allow you to fine tune the flow rate – initially and over time
 - How to calculate the required flow for the fan
 - Use a blower door fan to identify the stack effect of the house
 - Or, use trial and error with a variable-speed radon fan
- Available accessories – sound isolators, controls, ducts, dampers, bug screens, alarms, etc.

What are the details of the alternate method?

3. Equipment

- Fan controls
 - i. Accessible on/off switch
 - ii. Continuous, variable-speed
 - iii. Pressure difference controls
- Alarms
 - i. Purpose of alarm – let you know if the system isn't working
 - ii. Types of alarms – audio and signal light
 - iii. Alarm controls – pressure differential switch - Install a differential-pressure switch-activated alarm to let you know if the depressurization space fan fails

What are the details of the alternate method?

4. Follow-up

- Air quality tests after the system is in operation – verification that the IAQ is safe
- Adjust the fan flow, if necessary, based on IAQ test results
- Verify fresh air ventilation meets ASHRAE 62.2
- CAZ safety check
- Radon test under new indoor pressure mode
- Turn off the fan when it is no longer needed.
 - Check for odor at the radon fan outlet every two years.
 - Don't remove the fan in case you need to turn it back on.

What are the details of this alternate method?



Case study –
2020 to 2021

The problem

The foam is in all of the second-floor walls and roof slopes.

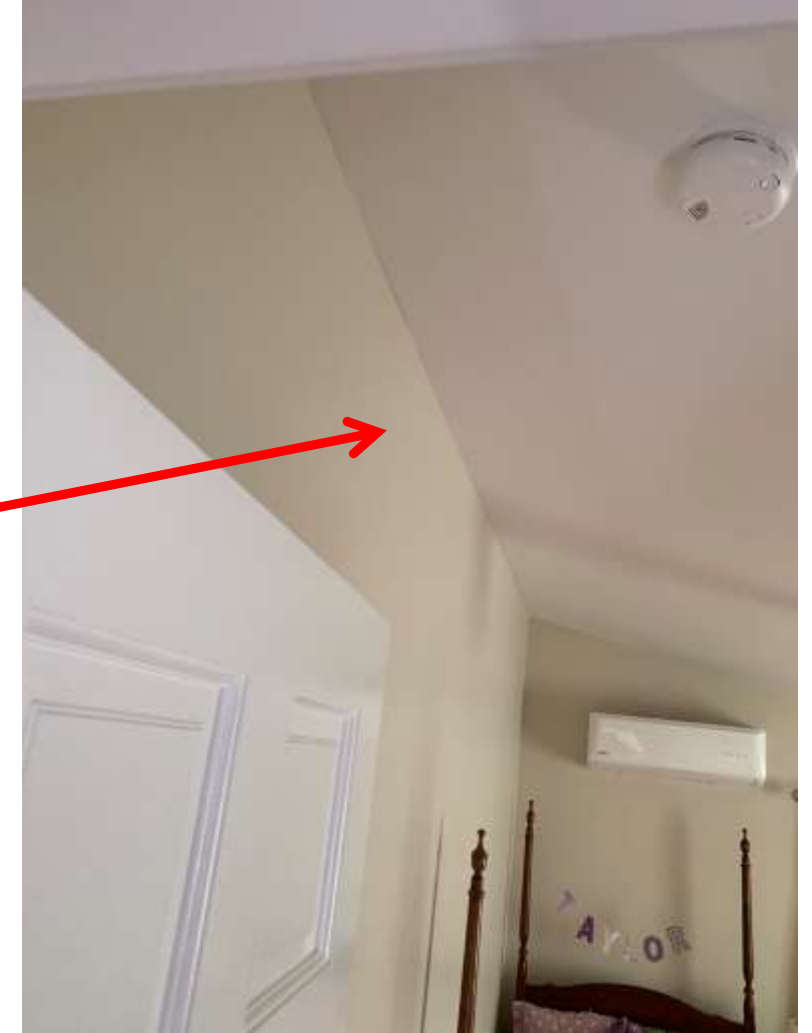
The Owners are experiencing burning eye symptoms and an odor. My air tests indicated that there was off gassing and that SPF was a likely source.

This is the second time this Installer has misapplied the foam in this house. The first time the Owner and his family had to move out, the contractor gutted the entire house, and then they rebuilt the building enclosure system and replaced the interior finishes. Now they find out that the replacement foam has also been misapplied. Now what?

Before the remediation

East End before implementing the interstitial depressurization method

Center wall in the Kid's bedrooms – no ridge beam



Before the remediation

West End before
implementing
the interstitial
depressurization
method



Ridge beam in
the Master
Bedroom

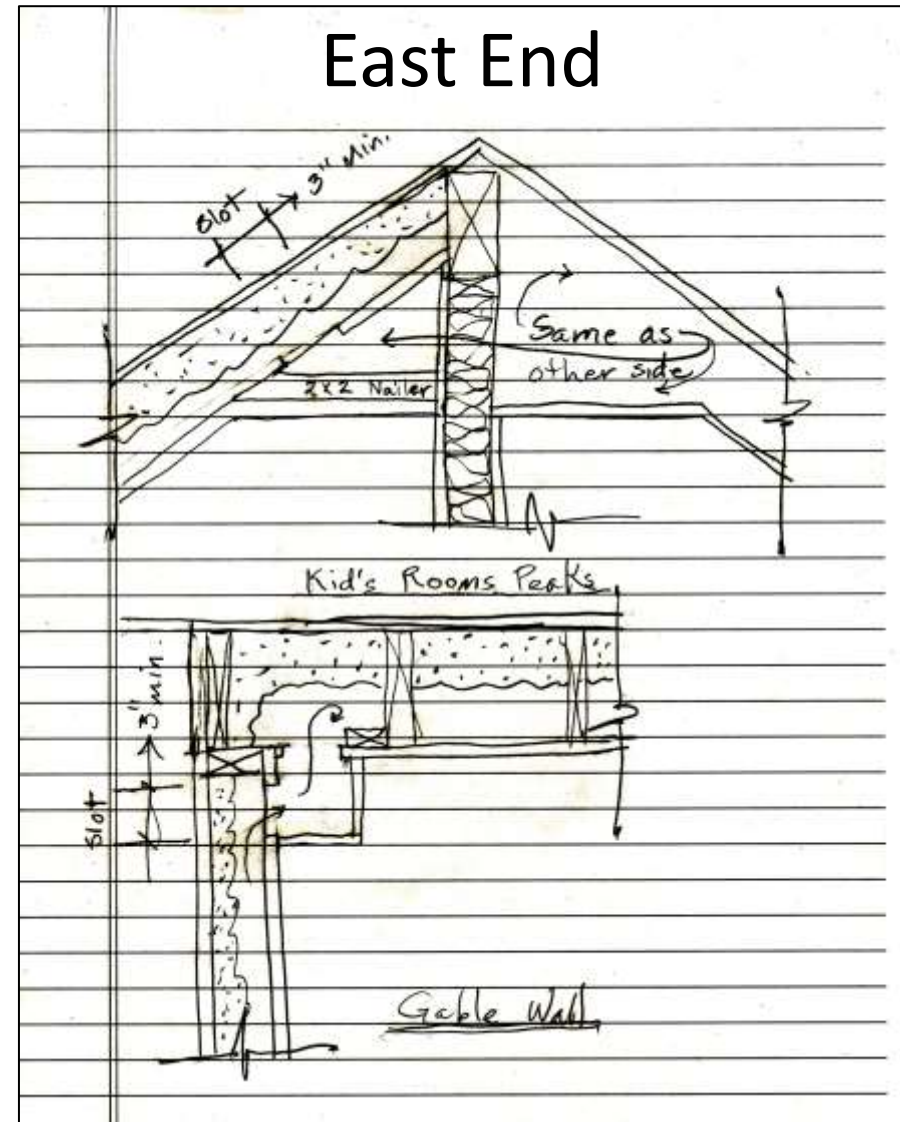
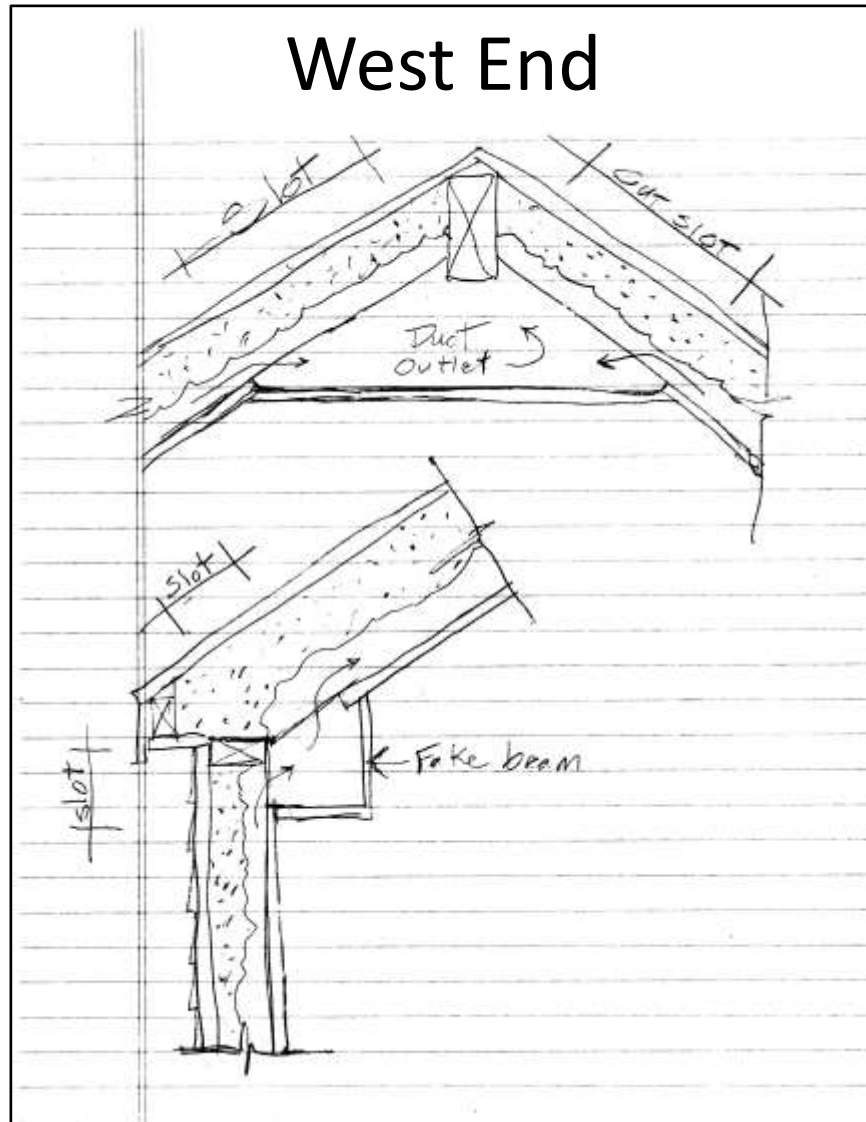
Before the remediation

Center
Hall



Ridge beam
in the Center
Hall

A lower cost solution



During the remediation

East End



Exposing the top of the interstitial spaces



During the remediation

Connecting the
plenum to the roof
rafter bays



Ridge duct connects the two roof slopes to the radon fan

Center Hall



Radon fan outside



Verification

- Following the installation of the system (no putty and paint yet) and a “refresh” period with the fan running, new air tests were performed.
- The tests showed that the chemical compounds that had been high before, were now all below the EPA exposure limits.
- The remediation plan was then completed.

What homeowners think about the method vs. remove and replace

7-14-21 “Henri,

The price I paid for you, doctors, air quality labs, and the contractor totaled about \$14,000.

The fan is working as my burning eye symptoms are gone and the odor is much less noticeable. If the odor increases in the dog days of August, I know I can just climb up and adjust the speed of the fan. The current (fan speed) level I have it at is 6 (out of a possible 10).

I’m thinking we can say the mission is complete. I’d be happy to talk to any of your other clients thinking of having this done to tell them about my pleasant experience with you and my experience with the fan. Any time!

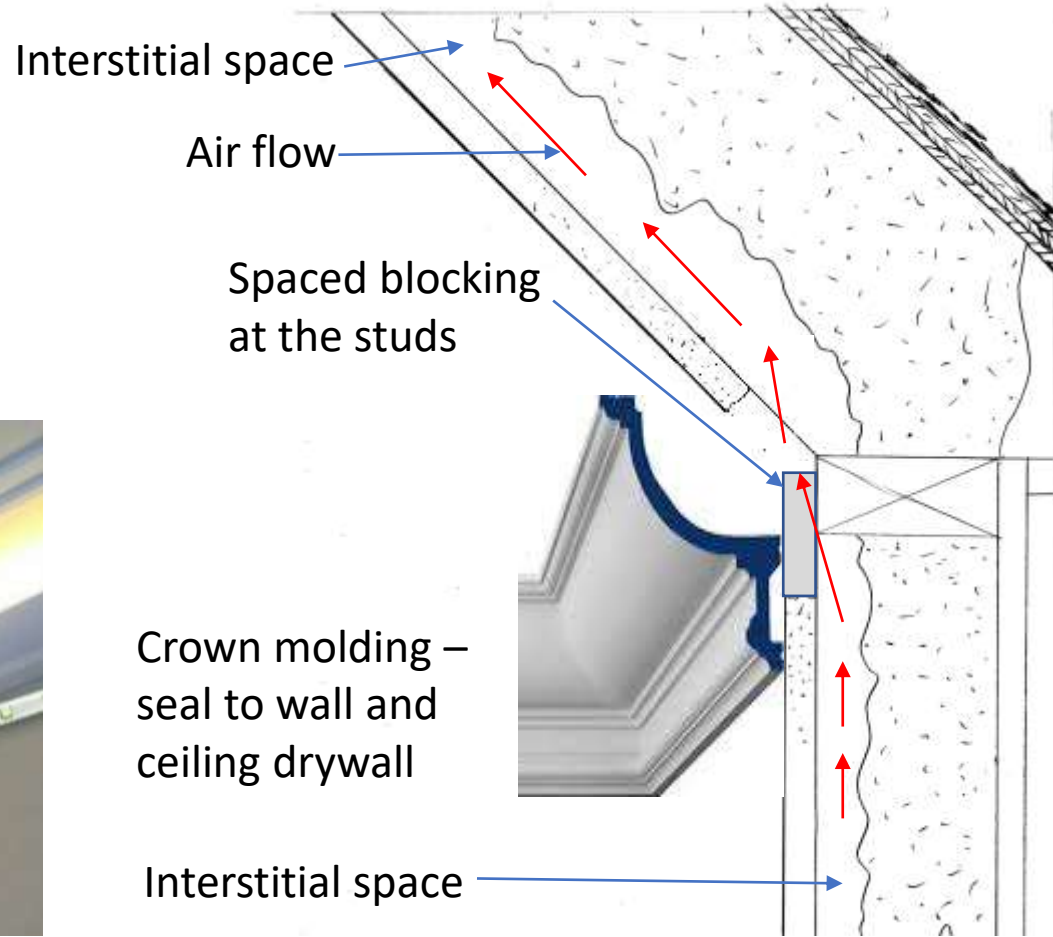
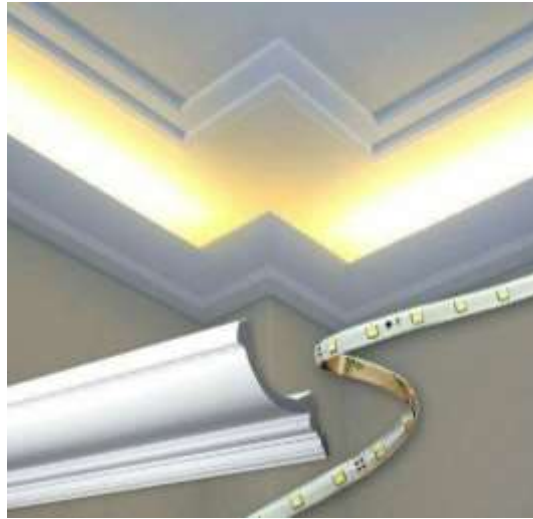
Thanks Henri”

Brennan Wall-to-slope ideas

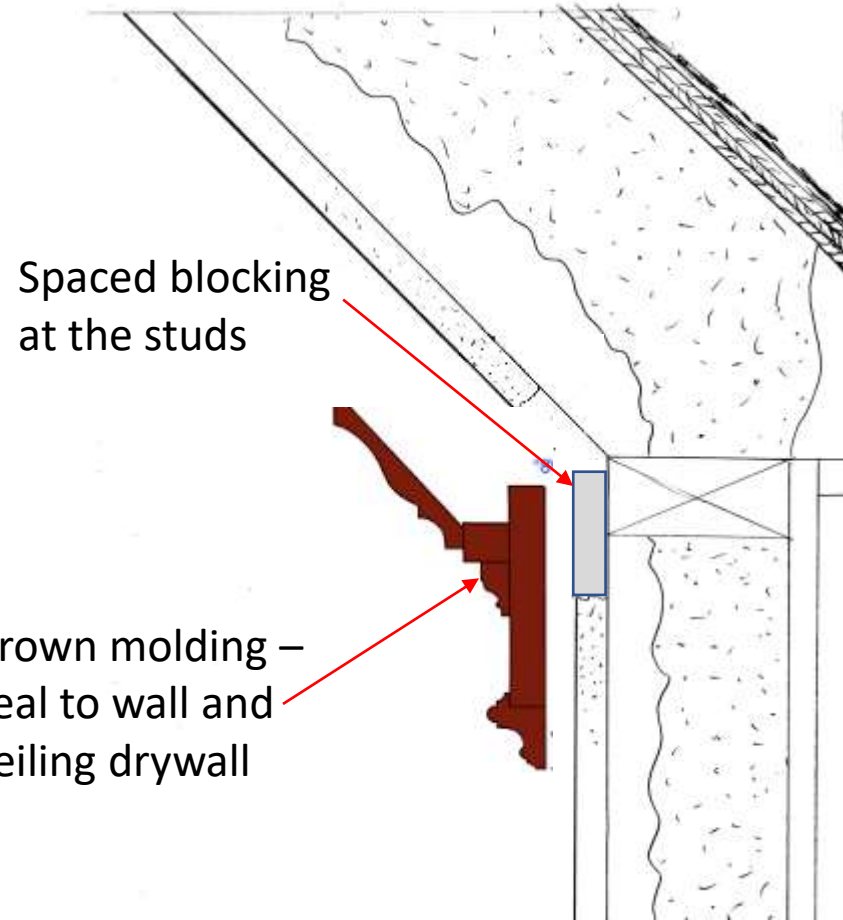
How to connect the wall space to the roof space and the plenum



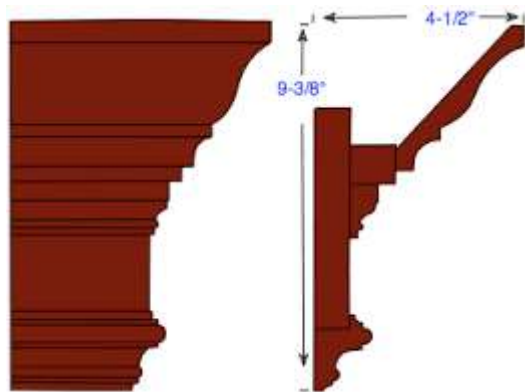
Lighting available



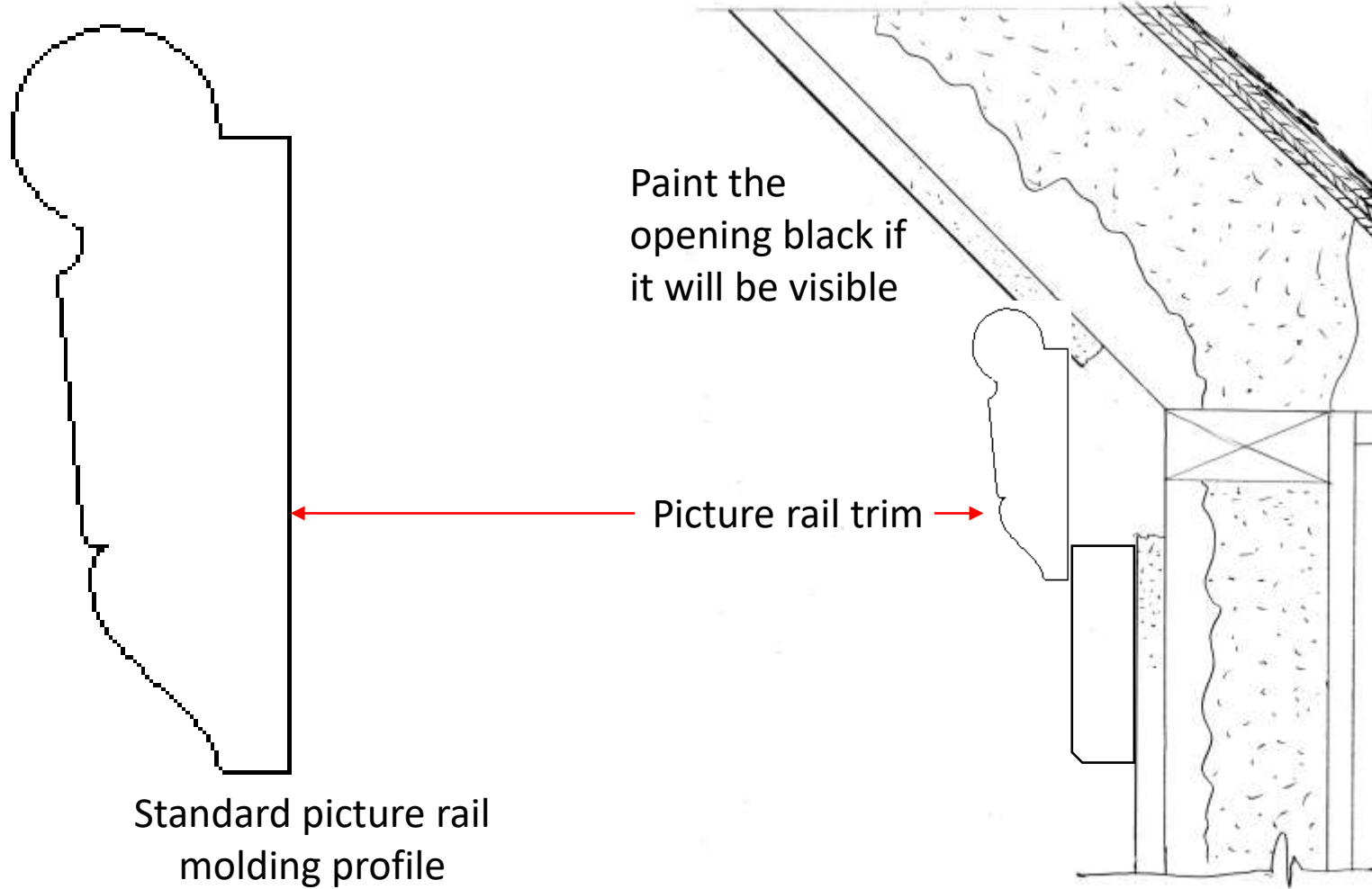
Brennan Wall-to-slope ideas



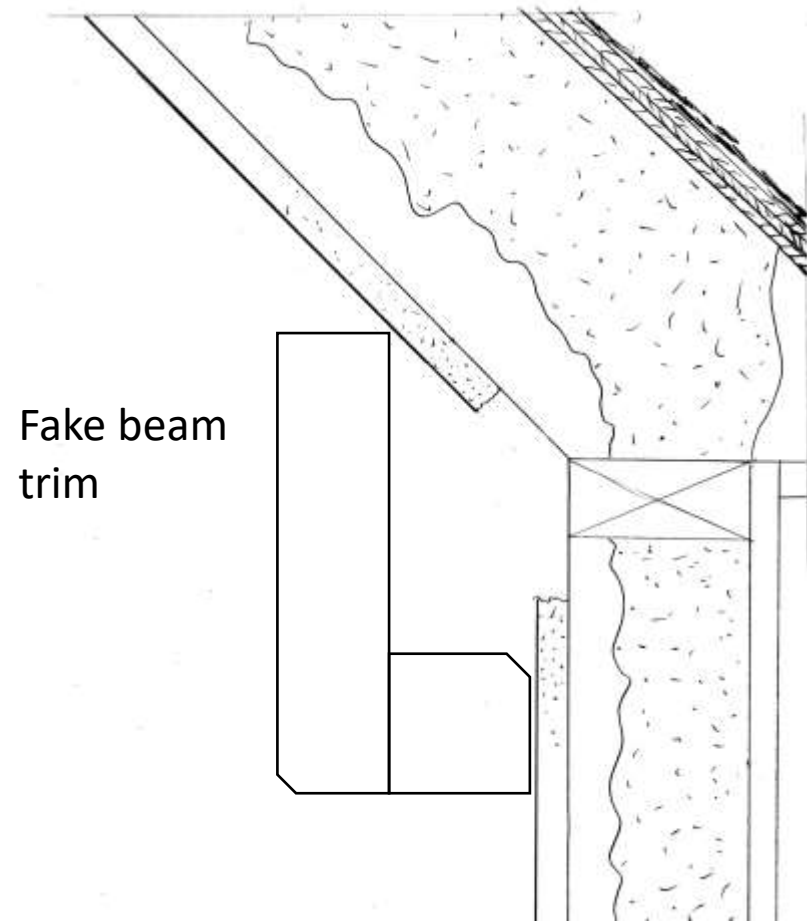
Lighting available



Brennan Wall-to-slope ideas



Brennan Wall-to-slope ideas



Fake beam trim

Other Interstitial space projects

- Basement (Richard - 2014)
- Attic (Zilkin - 2019)

Case Study - Basement Playroom Project - 2014

Evacuate if uncertain!

How do you know if it is safe?

Only IAQ testing will tell you for sure,
and even then, some chemical
compounds do not have EPA PELs.

Walkout basement with low-level ventilation

Basement play space for the kids!

Radon system under the floor – helped with Owner acceptance

Foam sample location



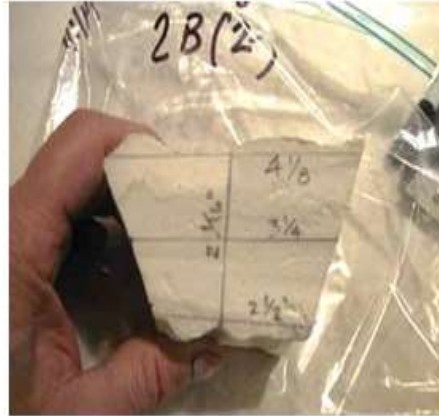
Walkout basement with low-level ventilation



Walkout basement with low-level ventilation

- These foam samples shrank when ASTM 2126 tests were performed.
- Odor increased with temperature during the tests. That's why most roof/attic complaints are in the summer.
- Note: shrinkage is in proportion to the density.

2B (2) Before painting and the hot box test:



2B (2) with VB paint and after the hot box test:



1B (2) Before the hot box test:



1B (2) After the hot box test:



Walkout basement with low-level ventilation

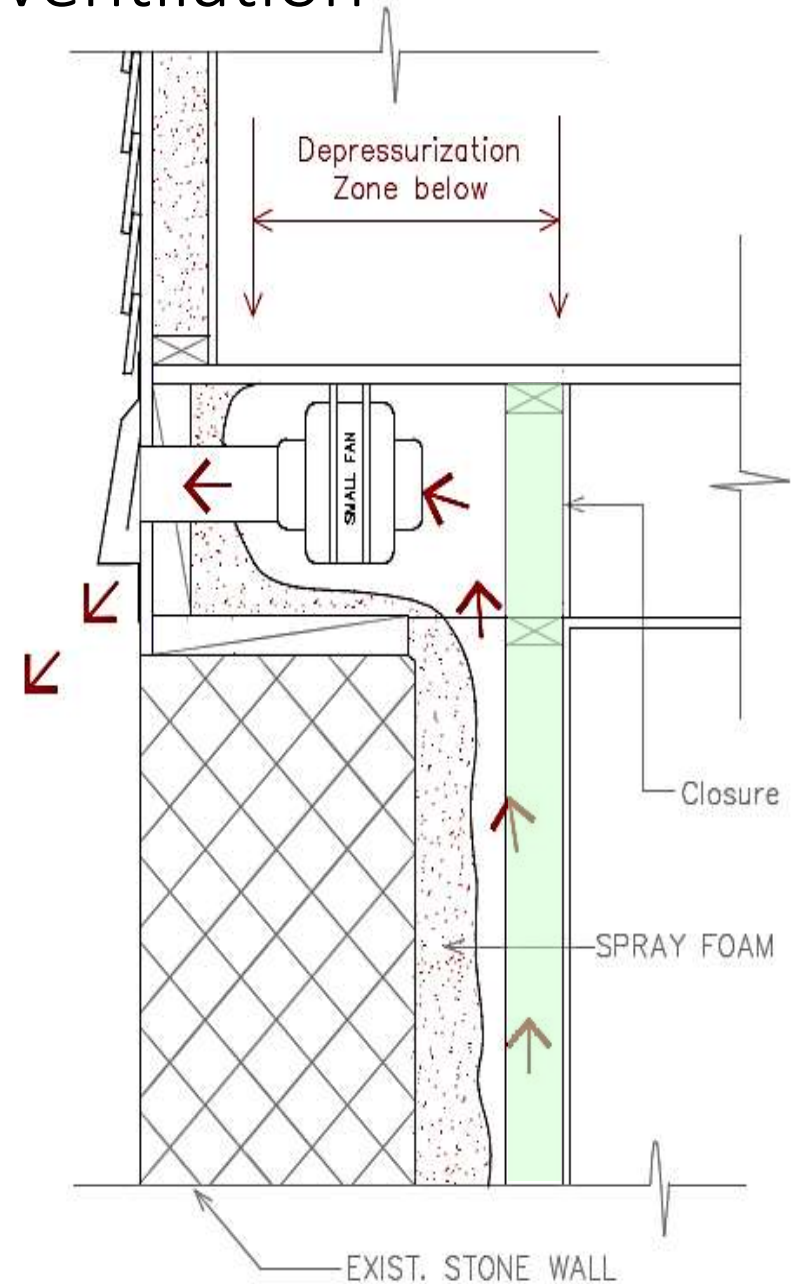
Isolation and local
depressurization
systems vs. bulk
ventilation – saves
energy and removal

Walkout basement with low-level ventilation

Isolation/low-level ventilation remediation method for out-gassing SPF

- Long-term depressurization
- Tight barrier
- Radon-type fan
- Pressure-differential switch
- Light or horn alarm for the fan

\$39.00



Instertial space verification

- Testing the isolation enclosure during construction with a Duct-blaster fan.
- Exhaust location should not be near an HVAC fresh air intake or outside play space.
- Out-gassing stopped after five years.



Zylkin Residence - 2019



Taking air quality samples



This system has the plenum along the bottom. The air flows up one slope, across the ridge, and down the other side to the plenum which runs along the floor and out through the fan.



The fan outlet is in the low edge of the roof as the gable walls are thick stone.



What homeowners think about the method vs. remove and replace

Email from Mark Zylkin – 12-30-20

“Hi, Henri

I had meant to let you know..... The System, as you designed it, was installed and it works, perfectly. Unfortunately, I have no photos.

The contract work renovating the Attic was finished late August/ beginning September 2020. So, the extraction fan system has been operational for nearly 4 months.

The happy couple are delighted in what is now their master bedroom, and no smells, fan noise or other inconvenience has been reported.

Jack particularly is very happy with the result, since he was the one who could smell the original “fish” smell and felt all was lost!

You can advise your clients your design of a low-pressure ventilation system to continually suck air out of the void between Drywall and Foam works and works properly.

Please accept this note as confirmation that your system design works, and should work for others.”

Thank you for your time!

QUESTIONS??

By: Henri Fennell, CSI/CDT
© H C Fennell Consulting, LLC 2023

www.polyurethanefoamconsulting.com

Cell: 802-222-7740