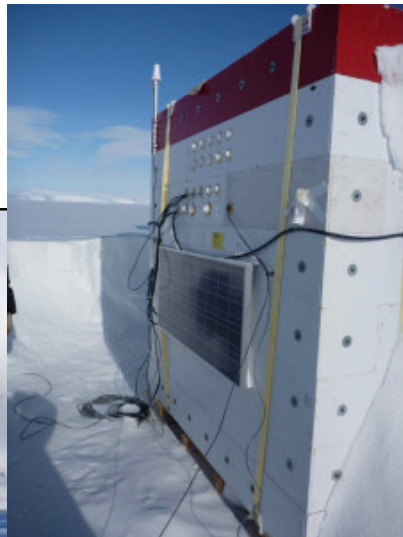


Henri is an architect and building envelope specialist with over forty years of experience in the construction industry. He was a pioneer in the solar industry, introduced the installation technique for field-applied closed-cell closed-cavity-fill polyurethane foam and has designed and constructed a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

Net zero in
Antarctica



The Big Dig



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, 4 American Ski Grande Hotels in the Northeast, Net-zero energy weather station in Antarctica, The Guggenheim Museum
6. Two US patents and numerous technical papers related to foam & foam QA



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The SPF “inside-out” brick cavity-wall remediation method

BREAKOUT SESSION 3E
THURSDAY, FEBRUARY 1
@ 10:15 AM
Location: 202B

Henri C. Fennell, CSI/CDT
H. C. Fennell Consulting, LLC
www.polyurethanefoamconsulting.com



ANTITRUST POLICY STATEMENT FOR SPRAY POLYURETHANE FOAM ALLIANCE MEETINGS

It is and shall remain the policy of the Spray Polyurethane Foam Alliance (“SPFA”), and it is the continuing responsibility of every SPFA member company, SPFA meeting or event participant, as well as SPFA staff and leadership to comply in all respects with federal and state antitrust laws. No activity or discussion at any SPFA meeting or other function may be engaged in for the purpose of bringing about any understanding or agreement among members to (1) raise, lower or stabilize prices; (2) regulate production; (3) allocate markets; (4) encourage boycotts; (5) foster unfair or deceptive trade practices; (6) assist in monopolization; or (7) in any way violate or give the appearance of violating federal or state antitrust laws.

Any concerns or questions regarding the meaning or applicability of this policy, as well as any concerns regarding activities or discussions at SPFA meetings should be promptly brought to the attention of SPFA’s Executive Director and/or its legal counsel.

Using the SPF “inside-out” brick cavity wall remediation method

Case study - S. Londonderry Elementary School (2004)

- Standard installation requirements: 2.1# Spray-applied polyurethane foam (SPF) capability – open walls
- Specialty installation requirements: 2.1# Injected polyurethane foam (IPF) capability – concealed locations behind structural members and between floors
- Diagnostic and/or QA requirements: adhesion testing, water testing, blower door testing, foam processing quality testing capabilities
- Specialty coating: Thermal barrier required in exposed areas
- Specialty accessory products: Drainage membrane, drainage mat in some applications

Using the SPF “inside-out” brick cavity wall remediation method

By way of introduction to this method, it was developed for moisture/mold remediation in an existing brick cavity-wall project where the back-up wall sheathing had become wet due to various airborne moisture transport mechanisms. Since that project, it has been used in similar retrofit situations that had flashing and drainage plane material failures.

It is appropriate for multi-story buildings and projects with wood-framed construction.

Using the SPF “inside-out” brick cavity wall remediation method

This alternative method was developed in 2004 to avoid removing the brick façade to replace the drainage plane, air barrier, and insulation in a New England school.



South Londonderry Elementary

Using the SPF “inside-out” brick cavity wall remediation method



Major remediation project – mold inside the brick cavity wall

Initial cavity wall inspection area. Problems noted include blocked weep holes, compromised capillary breaks, failing wall flashings, and no drainage plane to protect the sheathing.



Using the SPF “inside-out” brick cavity wall remediation method

The original problem: Through-wall air handler units were open to the brick cavity. Mold found in the cavity on the paper-faced drywall sheathing was determined to be the source of mold in the classrooms.



Using the SPF “inside-out” brick cavity wall remediation method

The key to this method is to manage the water that passes through the brick cladding (the rain screen) as you would in new construction, but while installing the drainage plane from the inside of the building.

In new construction, the back-up wall is installed and the airtight, vapor tight, and waterproof thermal envelope is installed from the outside before the brick ties are installed and the brick is laid.

In the reverse access scenario, the back-up wall is dismantled from the inside, exposing the back (inside) of the brick cladding. In most cases the through-wall flashing remains intact.

Using the SPF “inside-out” brick cavity wall remediation method

The goals of a newly installed system are as follows:

- Manage water in the cavity wall to prevent water intrusion to the inside.
- Reduce air leakage.
- Provide vapor control.
- Provide adequate insulation within the existing available cavity size.

Using the SPF “inside-out” brick cavity wall remediation method

The steps of the inside-out method:

Preparation

1. Clean out the bottom of the brick cavity and make sure the weep holes are open, inside and out.
2. Install protection mesh to protect the weep holes.
3. Do not remove the structural components, including the brick ties and their fasteners.
4. Repair any damaged through-wall flashings.
5. Isolate all through-wall passages from the brick cavity.
 - Windows, doors, louvers, etc.
 - Mechanical penetrations
6. Where necessary, prime or etch the exterior face of the metal studs or steel structural elements to assure SPF bonding.

Using the SPF “inside-out” brick cavity wall remediation method

Brick and metal studs after removing the wet sheathing and mold. Brick ties were preserved where possible.



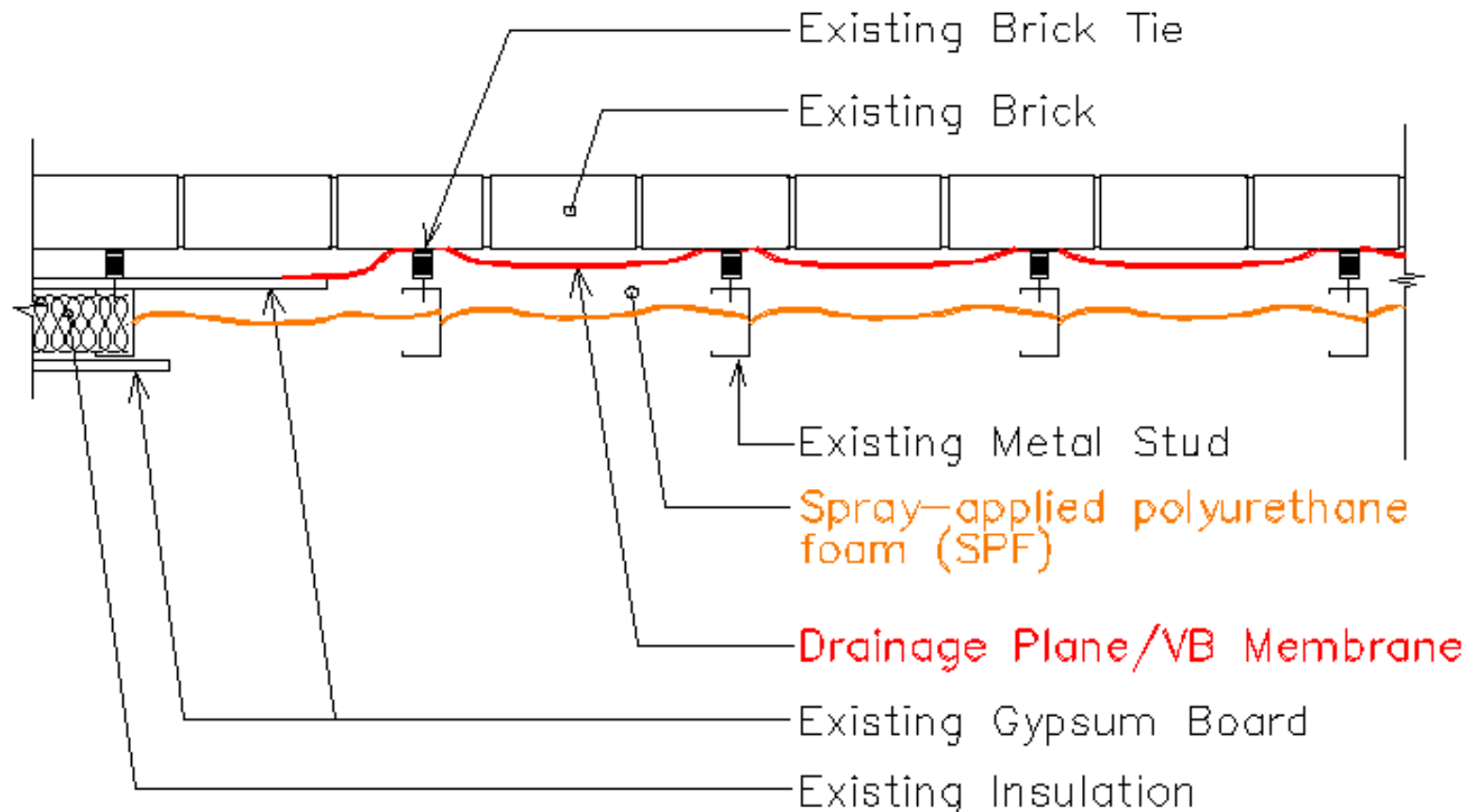
The existing conditions



Copper through-wall flashing was found mostly intact at the base of the wall

Using the SPF “inside-out” brick cavity wall remediation method

Horizontal section showing the existing brick and framing, the drainage plane location, and the profile of the SPF between the studs



Using the SPF “inside-out” brick cavity wall remediation method

This test was performed to verify the “cure lift” approach to maintaining a capillary break on the brick side. This method relies on the tendency of spray foam to lift during the cooling process when the substrate-side is unrestrained.



The strapping represents the metal studs in the brick walls



Using the SPF “inside-out” brick cavity wall remediation method

The steps of the drainage plane installation

1. Cut strips of the membrane (and spacer material if used) to fit between the framing members.
2. Install the spacer material against the brick if used.
3. Install the drainage plane membrane starting at the top of the wall (on the top floor if it is a multi-story building).
4. Lap the sections of membrane (if not one piece) to shingle them to shed water from the outside. Use strips of tape to position the membrane as required.
5. Tuck the bottom of the membrane down and to the outside of all through-wall flashings (windows, doors, louvers, relieving angles, etc.)
6. There can be narrow vertical spaces where the brick is exposed at each line of brick ties.

Using the SPF “inside-out” brick cavity wall remediation method

Install the spacer material against the brick, if used.



Install the spacer material to the bottom and on the outside of the flashing.

Using the SPF “inside-out” brick cavity wall remediation method



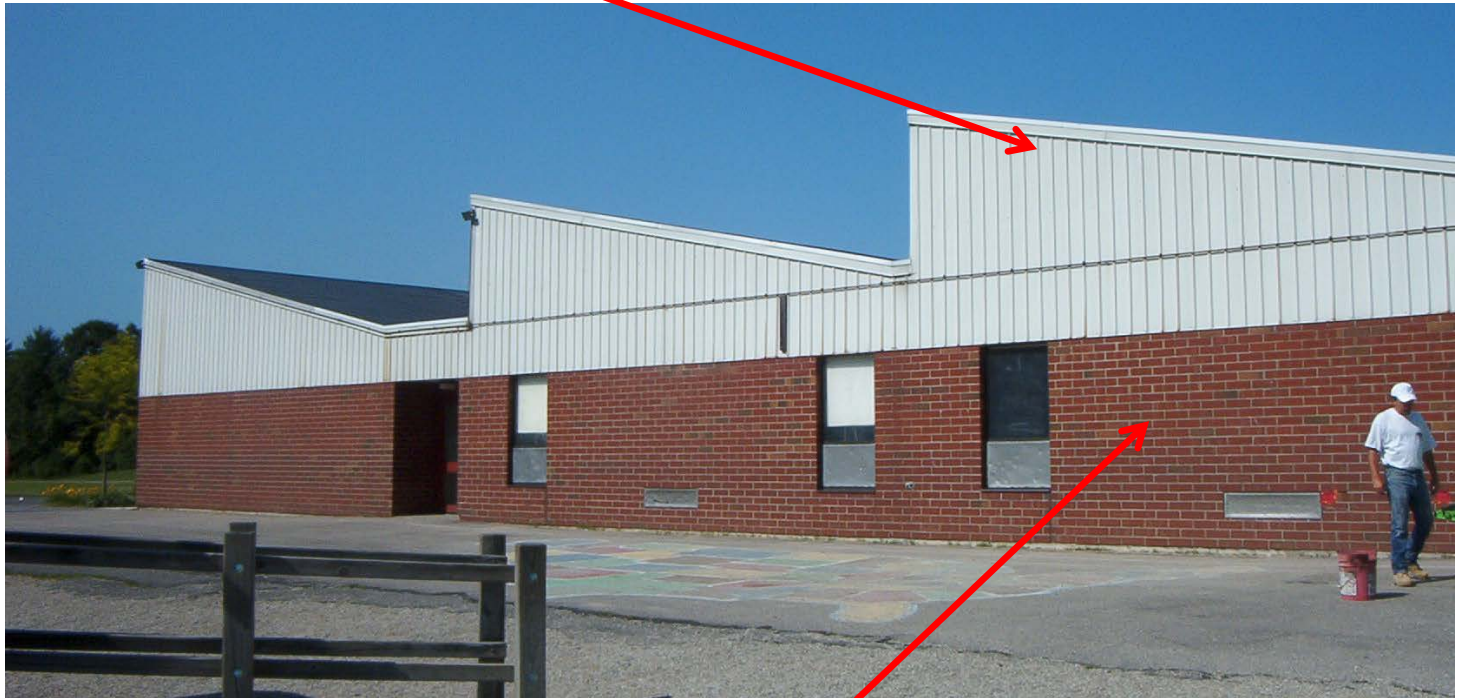
Goal: Maintain a capillary break behind the drainage plane

The S. Londonderry project used Cedar Breather to assure a capillary break space behind the drainage plane. Subsequent projects successfully use the “cure lift” approach to maintain the capillary break.

Using the SPF “inside-out” brick cavity wall remediation method

This building is a one-story structure with brick only on the bottom ten feet. Multi-story structures create floor-level transition problems that this building doesn't have.

Insulated metal panels



Brick facade

Existing metal wall panels and wall base flashing above the brick



Mesh and drainage membrane hung on clips on the metal panels



Drainage plane installed on the outside of the through-wall flashing

Using the SPF “inside-out” brick cavity wall remediation method

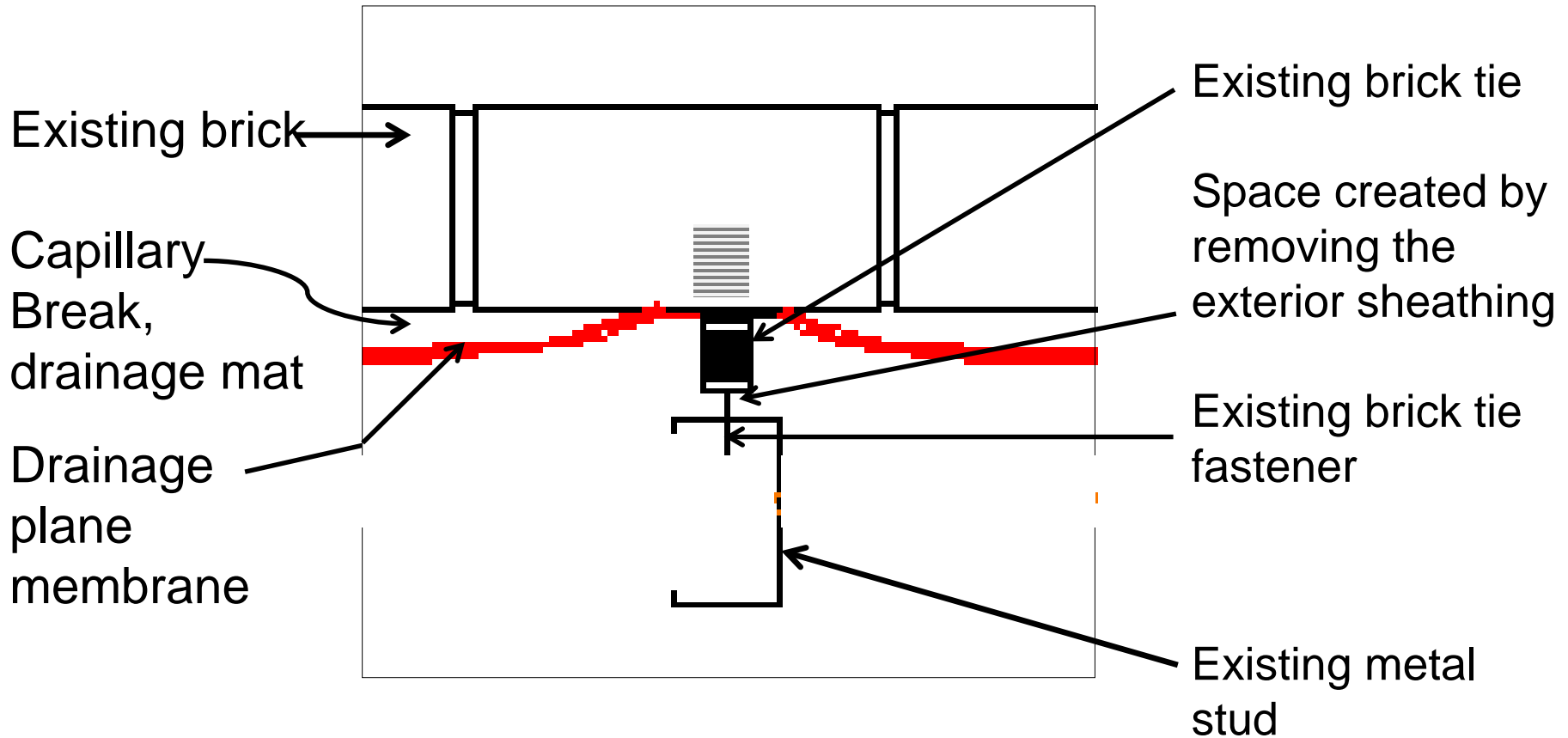


Install the drainage plane membrane starting at the top of the wall, even in multi-story structures.

Lap the sections of membrane (if not one piece) to shingle them to shed water from the outside. Use strips of tape to position the membrane if required.



Using the SPF “inside-out” brick cavity wall remediation method

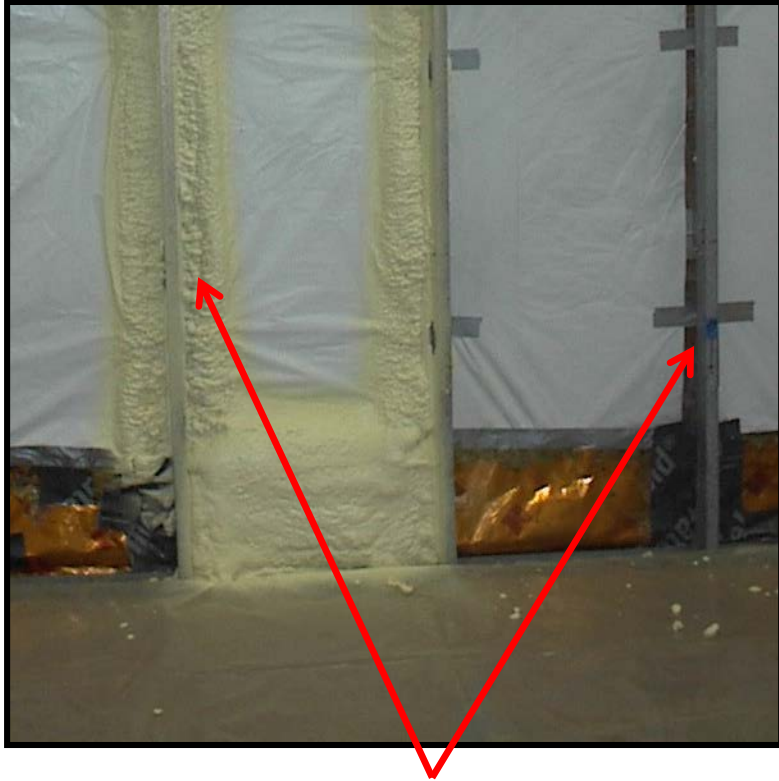


Using the SPF “inside-out” brick cavity wall remediation method

The spray foam installation

1. Follow all manufacturer installation and quality control requirements. Verify that all processing parameters are within the manufacturer's tolerances.
2. Isolate and ventilate the work zones. Maintain at least 4 ACH during and after the work.
3. Perform strip test shots and verify foam quality.
4. Install the SPF in vertical lines behind the studs to seal around the brick ties and where the drainage plane membranes meet.
5. Seal (flash coat) along flashing transitions and around penetrations (mechanical penetrations, relieving angle supports, etc.).
6. Fill in the wall bays after the picture frame areas
7. Perform any other required air sealing measures.

Using the SPF “inside-out” brick cavity wall remediation method

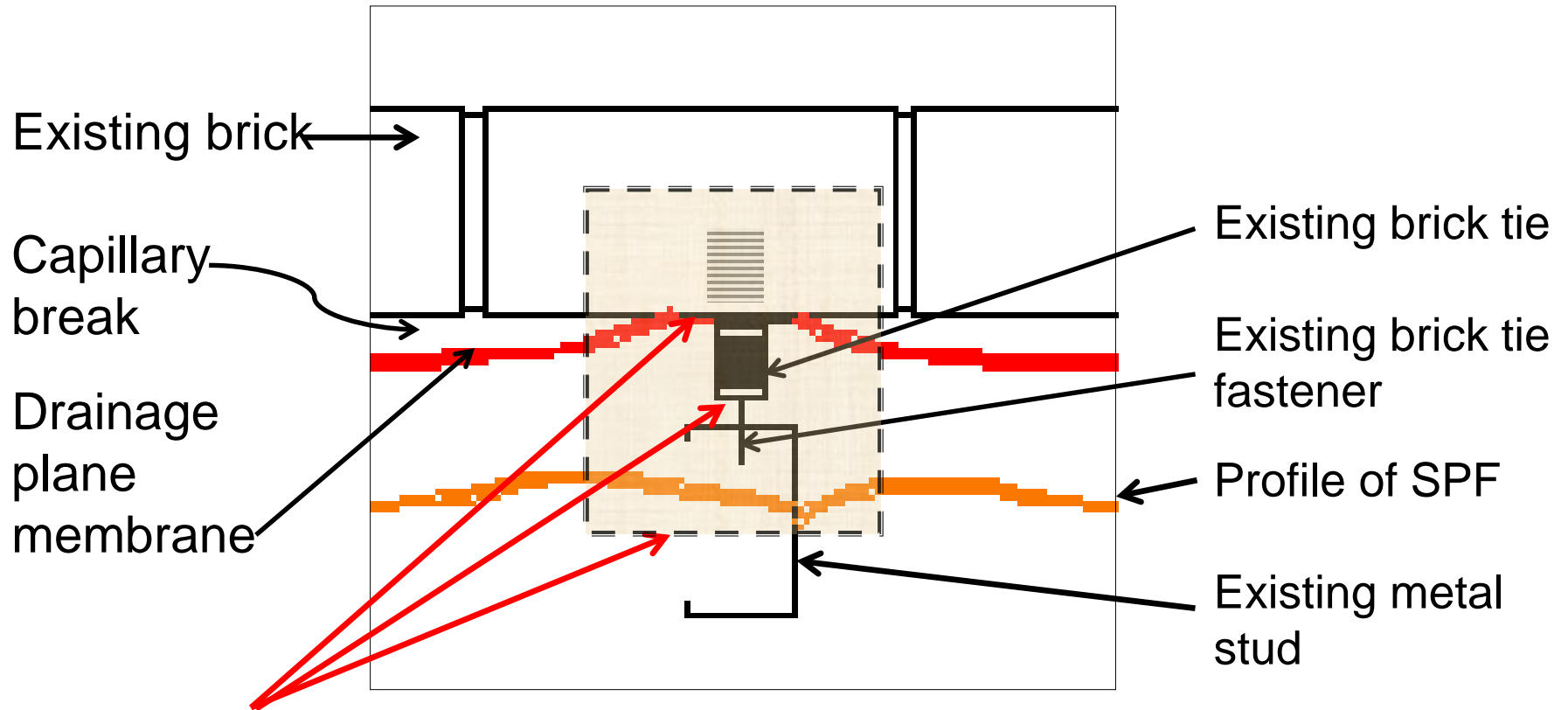


Install the SPF in vertical lines behind the studs to seal around the brick ties and where the drainage plane membranes meet.



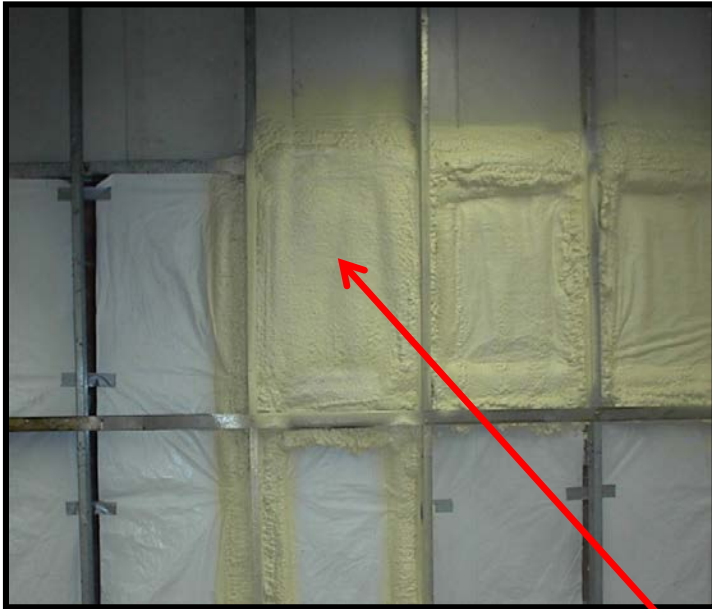
Flash coat the membrane to the through-wall-flashing before building up the insulation thickness

Using the SPF “inside-out” brick cavity wall remediation method



Filling this area first assures a seal around the brick tie and in the space originally occupied by the sheathing around the fastener.

Using the SPF “inside-out” brick cavity wall remediation method



Fill in the wall bays after the picture frame areas have set up. Install lift thicknesses as recommended by the manufacturer.



Using the SPF “inside-out” brick cavity wall remediation method

Safety and verification steps for the SPF inside-out method:

After the spray foam installation (before the drywall)

1. Maintain ventilation for the recommended cure and re-occupancy period (usually 24 to 72 hours).
2. Now is the time to make any additional repairs – test the entire air barrier system with a blower door before the drywall has been installed!
3. Perform water tests on the wall assembly to identify any leakage.
4. Verify that any through-wall appliances are sealed to the through-wall flashings.
5. Monitor energy performance when possible.

Using the SPF “inside-out” brick cavity wall remediation method

Perform any other required air sealing or insulation measures

SPF with a 15-minute thermal barrier was used to seal a major air leakage site at the wall panel-to-roof deck transition.

Ready for water test. Install the drywall finishes if there are no leaks.



Using the SPF “inside-out” brick cavity wall remediation method

Verification: Engineer’s water test to verify rain screen drainage



Using the SPF “inside-out” brick cavity wall remediation method

Finishes in progress



Using the SPF “inside-out” brick cavity wall remediation method

Energy Improvement vs. Cost for this project

- South Londonderry (renovation area ~ 38,000 sq. ft.)
- The energy use for this building has been reported to be about 40% lower for each of the past three years!
- Energy improvements by the contractor were about \$1.28 per square foot of floor area. Annual heating cost was \$0.83/sf. At \$0.35 savings per year, this remediation will pay for itself in less than four years.
- “Most green design is moving capital from the mechanical systems to the building enclosure system. Commercial construction is at the worst, a net zero proposition. We should be able to get a green building and not pay more for it, but this requires a good building enclosure and the mechanical system must be sized properly.”

Using the SPF “inside-out” brick cavity wall remediation method

The same Engineering firm requested us to replace the drainage plane, air barrier, and insulation in another New England school.

Molly Ockett Middle School

- Standard installation requirements: SPF capability – open walls
- Specialty installation requirements: IPF capability – **between floors**
- Diagnostic and/or QA requirements: adhesion testing
- Specialty foam product: 2.1# IPF foam formulation
- Specialty coating: None required
- Specialty accessory products: Cedar breather, drainage membrane
- Referral source: Building Science Engineer, School Board, Architects

Using the SPF “inside-out” brick cavity wall remediation method

Major remediation project –
water and mold found inside
the brick and concrete
masonry unit (CMU) cavity wall.



Molly Ockett Middle School

Using the SPF “inside-out” brick cavity wall remediation method



Problems noted during the initial cavity wall inspection include weep holes blocked, compromised capillary breaks, and missing or failing wall flashings.



Using the SPF “inside-out” brick cavity wall remediation method



Using the SPF “inside-out” brick cavity wall remediation method

Major remediation project – mold
inside the brick cavity wall



Using the SPF “inside-out” brick cavity wall remediation method



Using the SPF “inside-out” brick cavity wall remediation method

Only sections of this building were remediated. Some areas just at the bottom, other areas for the full height of the two-story building.



Specialty Field-Applied Foam Applications

Goal: Maintain a capillary break behind the drainage plane



The Molly Ockett project used Cedar Breather to assure a capillary break space behind the drainage plane. Start at the top.



Using the SPF “inside-out” brick cavity wall remediation method

Goal – replace the thermal envelope system with water-tolerant insulation and manage water entering the cavity



Install the spacer material
on the outside of the
through-wall flashing.

Install the drainage membrane
on the outside of the through-
wall flashing.



Using the SPF “inside-out” brick cavity wall remediation method



Install the SPF in vertical lines behind the studs to seal around the brick ties and to seal around where the drainage plane membranes meet.

Install the drainage membrane on the outside of the through-wall flashing.

Using the SPF “inside-out” brick cavity wall remediation method

Install the SPF in vertical lines behind the studs to seal around the brick ties and where the drainage plane membranes meet.



Flash coat the membrane to the through-wall-flashing before building up the insulation thickness



Using the SPF “inside-out” brick cavity wall remediation method



Install the SPF in vertical lines behind the studs to seal around the brick ties and where the drainage plane membranes meet.

Flash coat the membrane to the through-wall-flashing before building up the insulation thickness

Using the SPF “inside-out” brick cavity wall remediation method

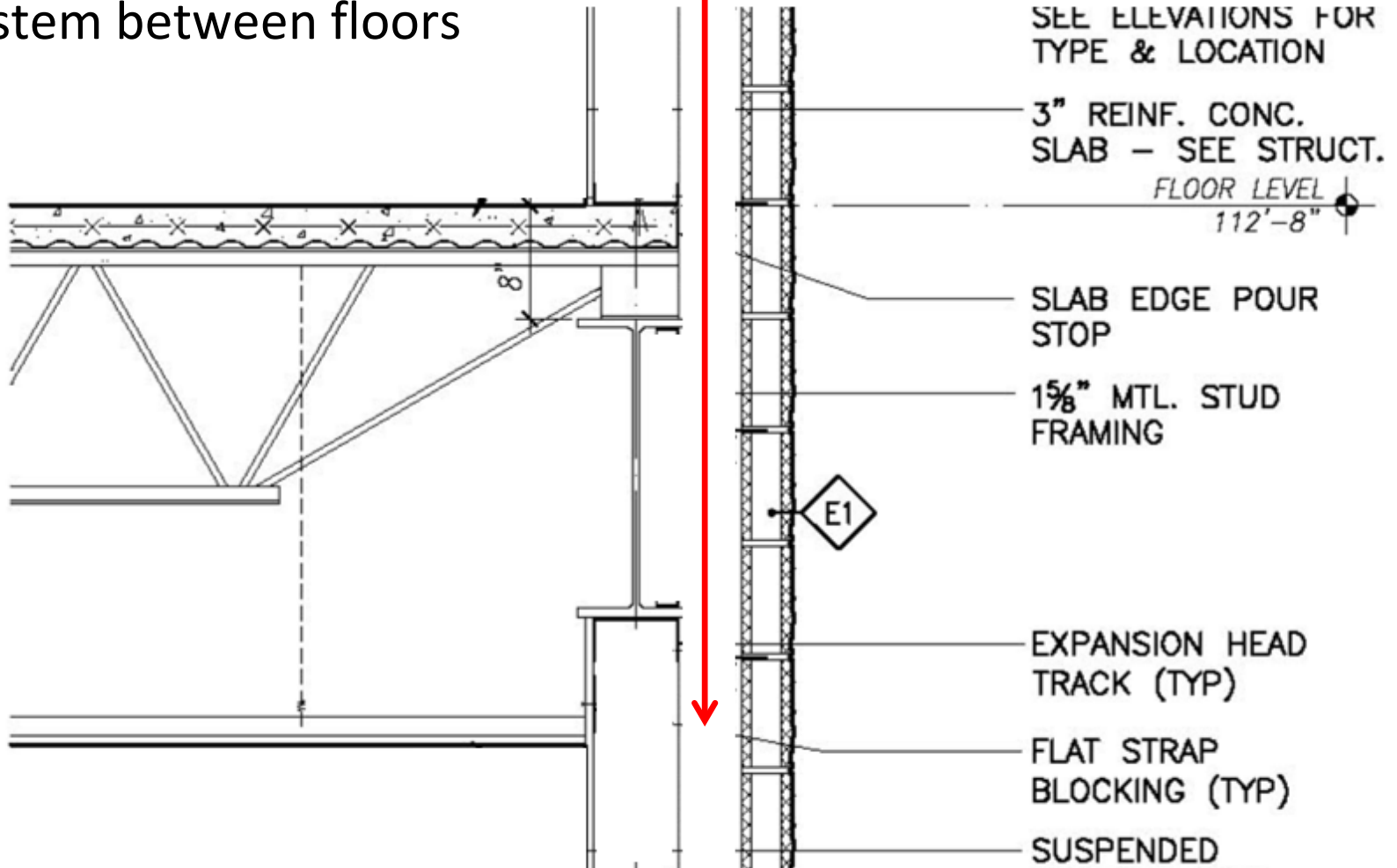


Fill in the wall bays after the picture frame areas have set up. Use lift thickness as recommended by the manufacturer.

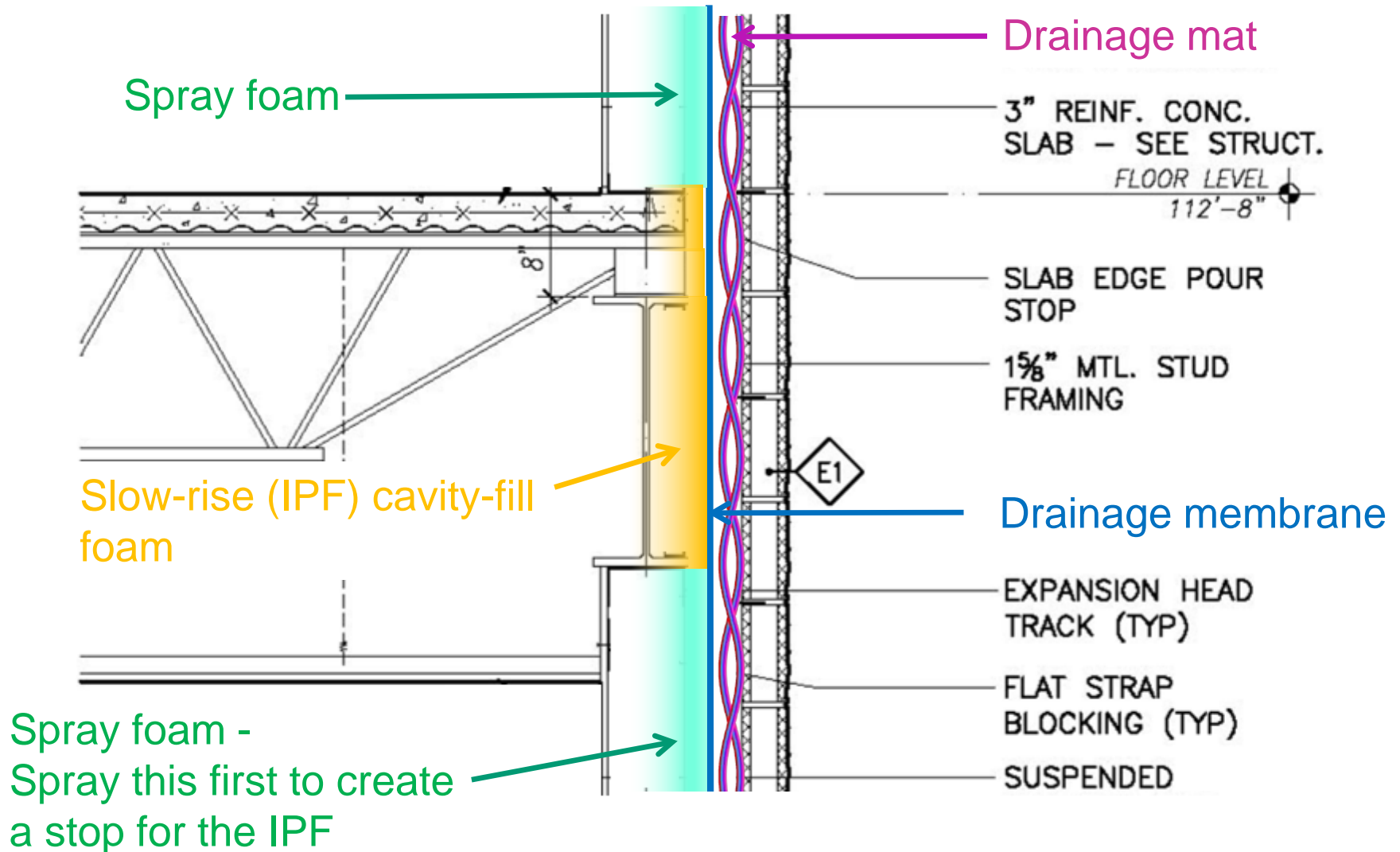


Using the SPF “inside-out” brick cavity wall remediation method

Maintain a continuous system between floors



Using the SPF “inside-out” brick cavity wall remediation method



Using the SPF “inside-out” brick cavity wall remediation method

Allen Memorial Museum – The Venturi Gallery

- Standard installation requirements: bulk SPF capability
- Specialty installation requirements: bulk IPF capability
- Diagnostic and/or QA requirements: Infrared camera
- Specialty foam product: 2.0# IPF (slow-rise) formulation
- Specialty coating: Intumescent thermal barrier paint in the soffits
- Specialty accessory product: None required
- Referral source: Building Science engineer, Facility operator, word of mouth in the industry

Using the IPF “inside-out” masonry cavity wall remediation method



- General building description/use – Allen Memorial Museum
- Oberlin, OH, Project date: 1998
- Problem addressed – Heat loss, air leakage, moisture migration
- Why IPF was the best solution – Original design has no vapor retarder

*Using the IPF “inside-out” masonry
cavity wall remediation method*

1976 Venturi Gallery –
Allen Memorial Museum



- R-value before and after – R-3 before vs. R-38 after
- Foam product/system used – Closed-cell froth IPF
- Techniques used – Drill and fill, open slots
- Quantity used – 4,600 lbs., \$2.90/bd. ft.

*Using the IPF “inside-out” masonry
cavity wall remediation method*



Venturi Gallery-Oberlin College

Using the IPF “inside-out” masonry cavity wall remediation method

Moisture damage to signature masonry cladding



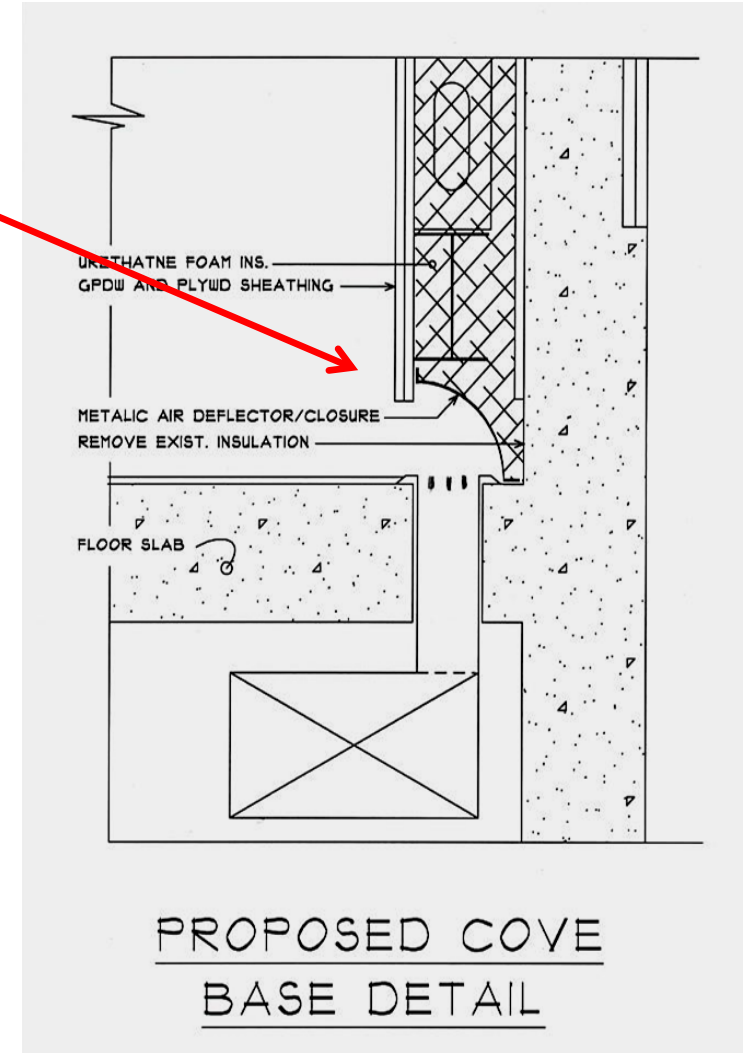
Using the IPF “inside-out” masonry cavity wall remediation method

Air and vapor permeable insulation



Using the IPF “inside-out” masonry cavity wall remediation method

Cavity open to HVAC system
The retrofit strategy



Allen Memorial Art Museum



March 21st,
2002



55
MM-1 The Use of Urethane
Foam Technology in Historic

Allen Memorial Art Museum



6-27-98

MM-1 The Use of Urethane Foam
Technology in Historic Renovation
and Remediation Work

*Using the IPF “inside-out” masonry
cavity wall remediation method*

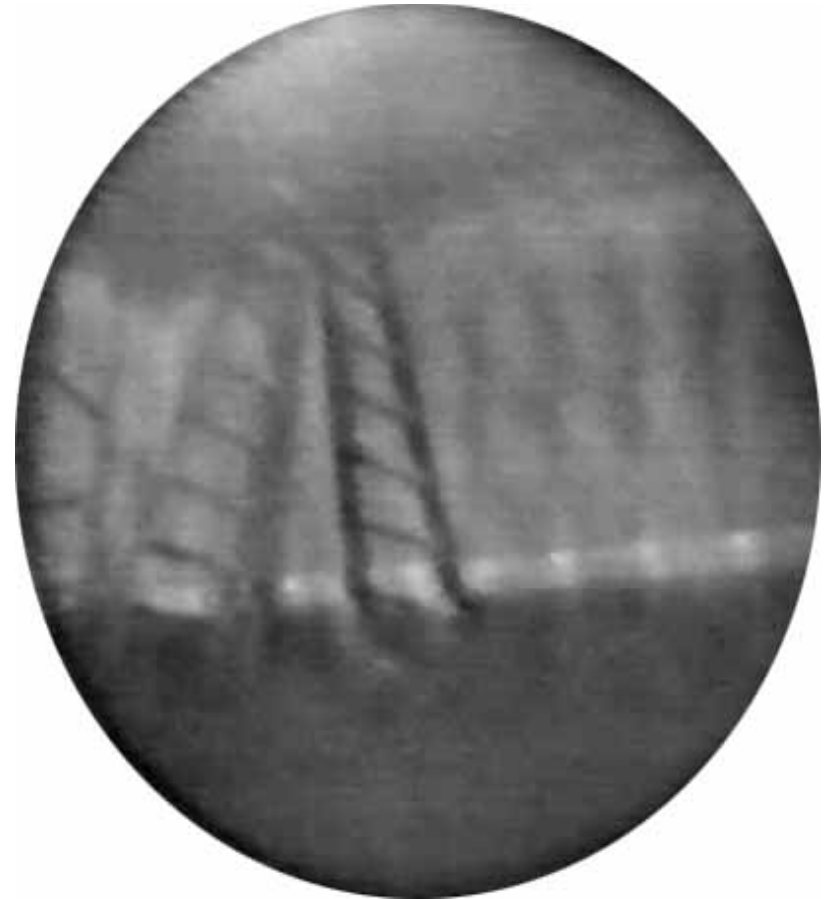
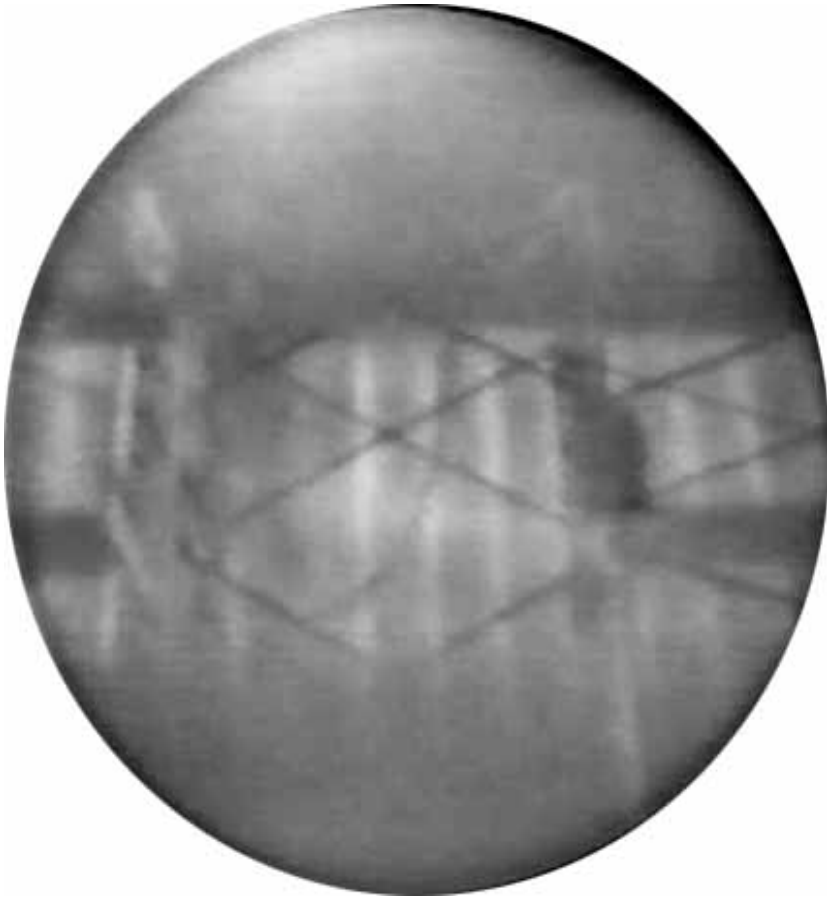


Venturi Gallery – Oberlin College

Using the IPF “inside-out” masonry cavity wall remediation method



*Using the IPF “inside-out” masonry
cavity wall remediation method*



Infrared QA

*Using the SPF “inside-out” brick
cavity wall remediation method*

Thank you for your time!
QUESTIONS??

By: Henri Fennell, CSI/CDT
HC Fennell Consulting, LLC ©2018
Cell: 802-222-7740

www.polyurethanefoamconsulting.com

Using the IPF cavity-fill method

Existing Schools

Thetford Elementary School curtain wall energy upgrade

- Standard installation requirements: Bulk SPF capability
- Specialty installation requirements: Bulk IPF capability
- Diagnostic and/or QA requirements: Infrared camera
- Specialty foam product: 2.0# SPF and IPF formulations
- Specialty coating: Coating or membrane for glass-side UV barrier
- Specialty accessory product: Same
- Referral source: HVAC engineer, Facility operator, school board, word of mouth in the district

Using the IPF cavity-fill method

IPF insulation covers 75% of the curtain-wall as part of energy upgrade for local elementary school (Photos taken in 2013, work completed in 1982 – Fill cavity behind the white UV membrane and green spandrel panel areas)



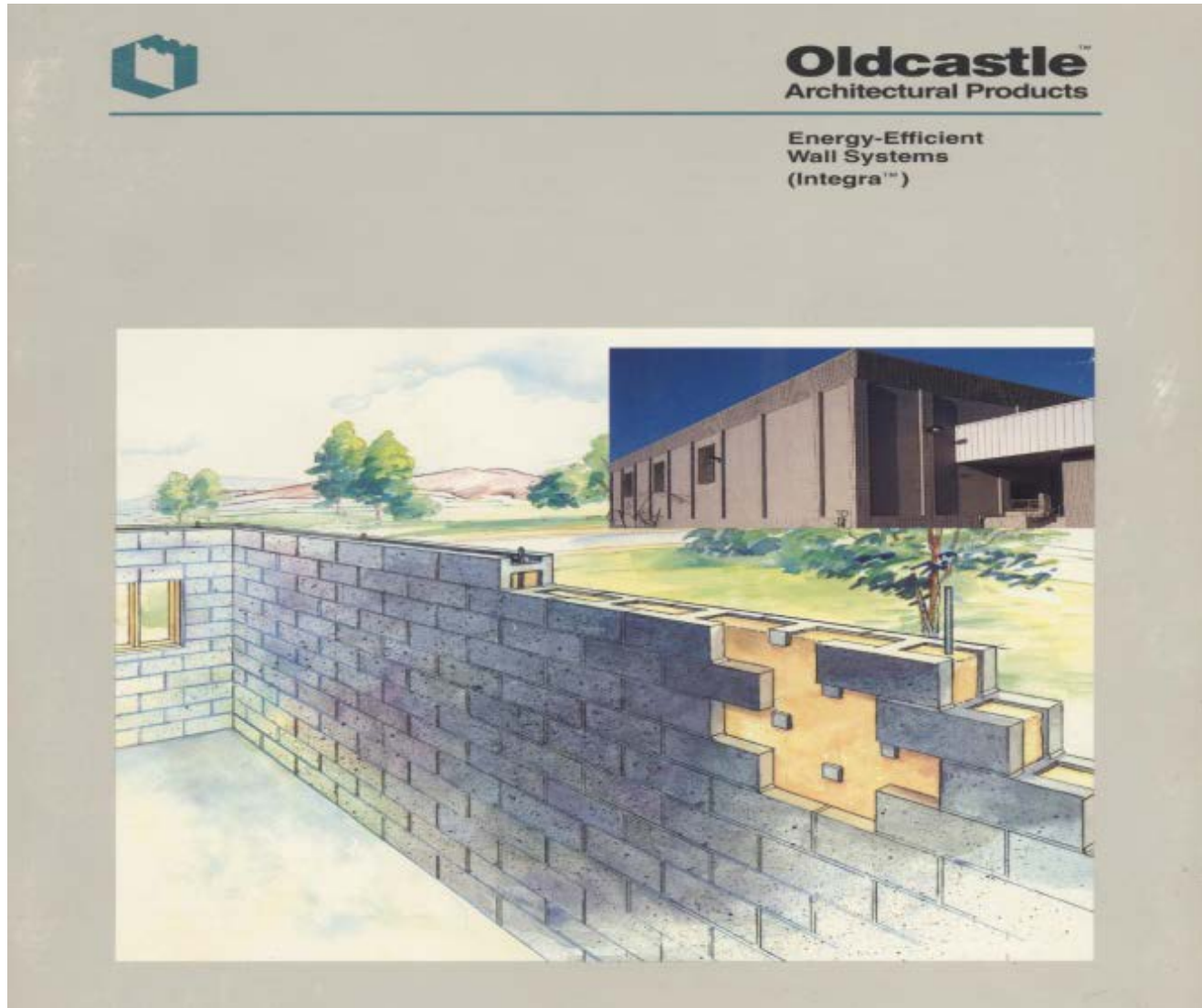
Photos taken in 2013, thirty-three years after the installation

Using the IPF CMU cavity-fill method

Wing's Market

- Standard installation requirements: SPF capability
- Specialty installation requirements: IPF capability
- Diagnostic and/or QA requirements: None required
- Specialty foam product: 2.5# IPF formulation
- Specialty coating: None required
- Specialty accessory product: Low conductivity masonry system
- Referral Source: Builder, Local block plant, National masonry distribution company, Local masons

Using the IPF CMU cavity-fill method



The Integra Wall System has minimal thermal bridging

Using the IPF CMU cavity-fill method



- General building description/use – Wing's Market
- Fairlee, VT, Project date: 2002
- Problem addressed with IPF – Insulation (H, A, M)
- Why IPF was the best solution – High R and moisture tolerant

Using the IPF CMU cavity-fill method



Using the IPF CMU cavity-fill method



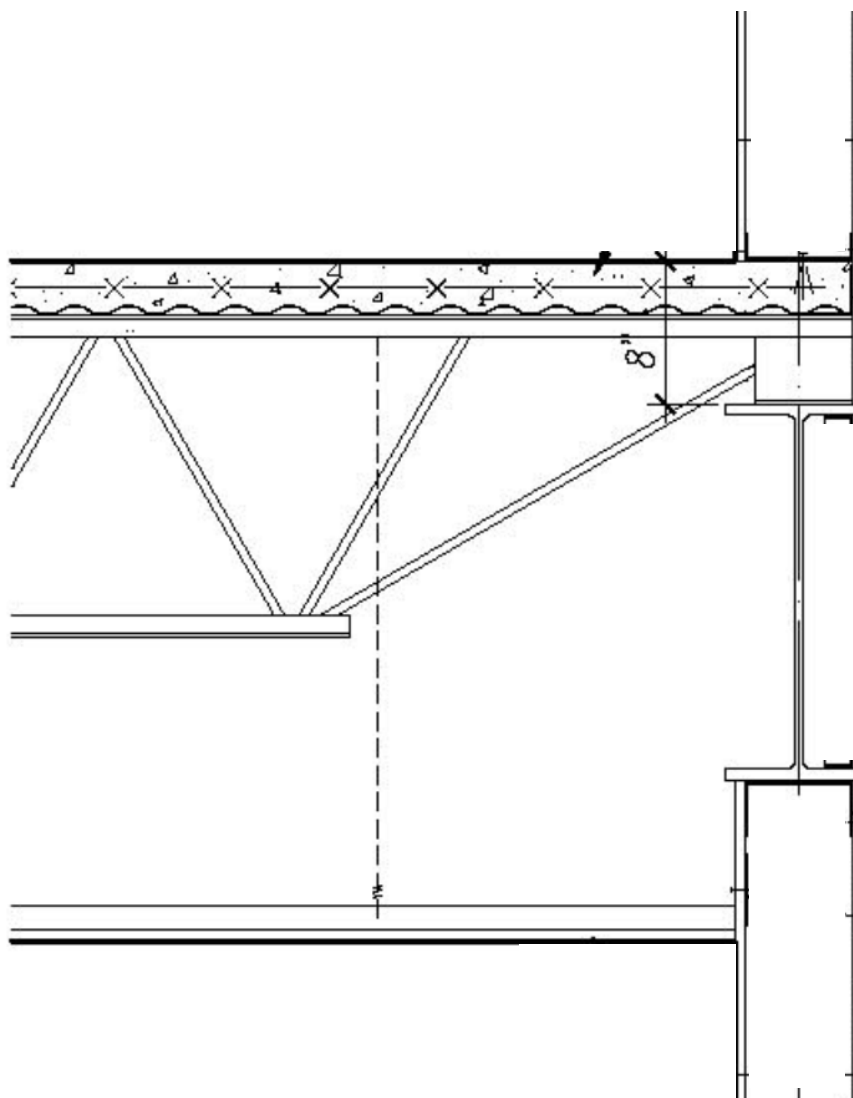
Using the IPF CMU cavity-fill method



Using the IPF CMU cavity-fill method




- R-value – 8" Standard block = R-3 with IPF, 8" Integra = R-21
- Foam product/system used – Closed-cell slow-rise IPF
- Techniques used – Open-top progressive fill



SEE ELEVATIONS FOR
TYPE & LOCATION

3" REINF. CONC.
SLAB - SEE STRUCT.

FLOOR LEVEL
112'-8" 

SLAB EDGE POUR
STOP

1 5/8" MTL. STUD
FRAMING

E1

EXPANSION HEAD
TRACK (TYP)

FLAT STRAP
BLOCKING (TYP)

SUSPENDED