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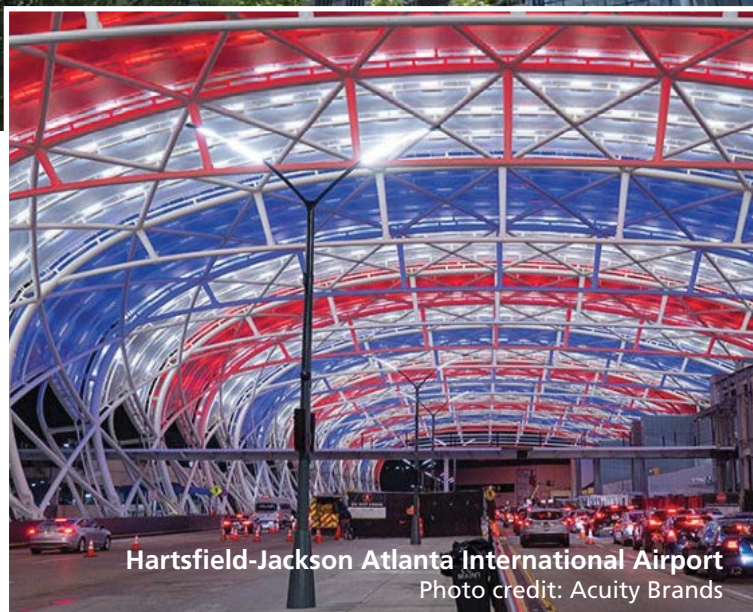
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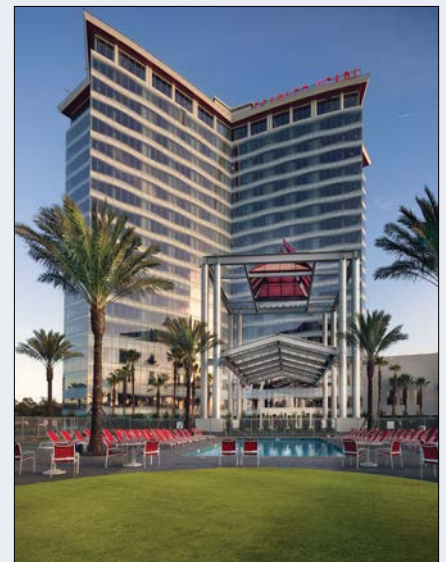




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An HVHZ-rated facade assembly, whether a ventilated rainscreen, EIFS, stucco system, or prefabricated panelized wall, must pass the industry's most demanding performance tests. These evaluations simulate the combined stresses building envelopes experience during extreme weather events.

PHOTO COURTESY STO CORP.
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123 North Pitt Street, Suite 450, Alexandria, VA 22314
Tel: (800) 689-2900, (703) 684-0300 Fax: (703) 236-4600
csi@csinet.org | www.csiresources.org

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Mark Dorsey, FASAE, CAE, mdorsey@csinet.org

BUSINESS DEVELOPMENT

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jcramp@kenilworth.com
Dave Flaherty | Editor
dflaherty@kenilworth.com
Amrit BLS | Online Editor
amrit@kenilworth.com

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elove@kenilworth.com
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HOW TO REACH US

266 Elmwood Ave. #289, Buffalo, NY 14222, (866) 572-5633

Production Offices

30 Leek Crescent, Suite 201, Richmond Hill, ON, Canada L4B 4N4, (905) 771-7333

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Dynamic Fan Testing

Validating Facade Performance Under Simulated Wind-driven Rain



By Landon Wade,
Luke Niezelski, P.E.,
and Christopher Grey
PHOTO COURTESY SIMPSON
GUMPERTZ & HEGERS (SGH)

As performance demands on building enclosures must meet high standards for durability, weather, and energy performance, facade systems are becoming more complex. These systems remain vulnerable to water infiltration without proper detailing, fabrication, and installation. Poor water management can lead to significant issues, including material

deterioration, corrosion, organic growth, and damage to interior finishes. These failures often result in costly repairs, construction delays, and potential litigation. Design alone does not guarantee reliable long-term performance in the field. Variability in design, fabrication, installation, cross-trade coordination, and site conditions can affect system performance. As a



Using Dynamic Pressure. This standard establishes procedures for evaluating the water penetration resistance of exterior fenestration systems, including curtain walls, storefronts, windows, and doors. The test attempts to simulate wind-driven rain by directing airflow from a high-speed fan toward the facade while water is uniformly applied through a spray rack system. The combination of airflow and water application creates pressure conditions that more closely replicate actual weather exposure than static testing methods. This testing has traditionally been used primarily for large-scale performance mockups due to the size of the required equipment (e.g. large airplane engines). With the development of smaller fans, this testing is becoming increasingly common at construction sites (see Photo 1), though AAMA 501.1-17 is a laboratory-based standard. The Fenestration and Glazing Industry Alliance (FGIA) is developing a field-based standard that is likely to be published in late 2026. A few of the forthcoming updates are summarized at the end of this article.

Although AAMA 501.1 is commonly referred to as a “dynamic” pressure test, the test itself does not create fluctuating or cyclic pressure conditions. Instead, the fan produces a steady airflow toward the facade, resulting in relatively constant pressure across the test area. The term

Photo 1: With the development of smaller fans, dynamic fan testing is becoming increasingly common at construction sites.

PHOTO COURTESY SIMPSON GUMPERTZ & HEGER'S (SGH)

result, field testing is critical to verification, providing objective data to confirm assemblies meet performance expectations.

Dynamic fan testing is one of several methods used to evaluate water penetration resistance. The primary standard used for this testing is AAMA 501.1-17, *Standard Test Method for Water Penetration of Windows, Curtain Walls, and Doors*



Left - Photo 2: AAMA 501.1 testing may be conducted on laboratory or field mockups before construction.

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Right - Photo 3: AAMA 501.1 testing may be conducted on installed assemblies to confirm installation quality and identify deficiencies before project completion.

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“dynamic pressure” refers to the pressure generated by moving air rather than the static air pressure differential created within a sealed chamber. When properly executed, dynamic fan testing serves as a valuable tool within broader enclosure testing, aiding other methods and confirming overall system performance. This article aims to provide a better understanding of the general testing procedure and its benefits.

Applications and advantages

AAMA 501.1 testing may be conducted on laboratory or field mockups before construction (see Photo 2), and on installed assemblies to confirm installation quality and identify deficiencies before project completion (see Photo 3).

It is also frequently used during investigations of existing buildings to help identify leakage pathways and evaluate facade performance under simulated wind-driven rain conditions. This can be particularly useful when leaks are difficult to reproduce using conventional hose testing methods.

Dynamic fan testing is most applied to buildings with unitized curtain walls (see Photo 4 on page 10), where interior chamber construction is impractical and time-consuming. The test is also valuable for simpler facades, as it can quickly assess a wide area.

In some cases, AAMA 501.1 testing may also be used as an alternative to ASTM E1105, *Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference*, when chamber installation is impractical, disruptive, or cost-prohibitive. Unlike chamber testing, which requires sealing the perimeter of the test area and establishing a static pressure differential within the assembly, AAMA 501.1 uses airflow generated by a high-speed fan to create dynamic pressure conditions at the exterior. Therefore, the method is often more efficient in the field, with less disruption to interior spaces and building occupants. AAMA 501.1 is not intended to replace ASTM E1105 in all situations, but it can be a practical and effective alternative in some cases. It is crucial to discuss the application of this testing with all stakeholders, such as the installer and manufacturer, as some products may not be certified under AAMA 501.1.

Testing basics, setup, and calibration methods

Proper setup and calibration are critical to obtaining valid, reproducible results. While recalibration is not required for every test, it is ultimately up to the testing agency to determine. Currently, recalibration is required at least every

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Top left - Photo 4: Dynamic fan testing is mostly applied to buildings with unitized curtain walls.

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Bottom left - Photo 5: Fans should be lifted onto the elevated work platform using appropriate equipment and trained personnel.

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six months. The following step-by-step procedures combine the author's methods with AAMA 501.1-17 guidelines.

Fan and equipment inspection

- Fan blade clearance—Visually inspect that fan blades are not touching the guard. Clearance must be uniform around the entire perimeter. Any contact indicates improper installation or damage requiring correction before operation.
- Mounting security—Verify all securing straps, bolts, and fasteners are tight. Secure any excess strap material away from rotating components.
- Work area clearance—Ensure no unnecessary objects or individuals are positioned in front of the fan. Do not activate the fan in environments around loose debris, such as leaves, dust, paper, or construction materials, as high-velocity airflow will propel them.

Placement and securement

- Inspect the elevated work platform thoroughly before lifting the fan. Remove all debris, loose materials, and potential hazards.
- Position the platform or mounting structure on the elevated work platform on a level surface to securely support the fan.
- Lift the fan onto the elevated work platform using appropriate equipment and trained personnel (see Photo 5).
- Secure the fan to the elevated work platform structure using all provided attachment points, straps, and fasteners. All securing hardware must be tight and verified secure.
- Verify that the base of the elevated work platform is in firm contact with the ground. Ground contact stabilizes the entire assembly and is essential for accurate velocity measurements during calibration.

There are many ways to mount a high-speed fan, depending on its size and the project site's requirements. A large turbo-prop-style fan, commonly used by dedicated testing companies, would typically be mounted to telehandler-style mobile forklifts (see Photo 6 on page 11). Smaller purpose-built fans can be placed within aerial lifts.

Velocity measurement setup

Velocity calibration is arguably the most critical step in AAMA 501.1-17 testing. Velocity must be



measured at four quadrants of the fan discharge face to verify uniform airflow across the test area. All velocity measurements are performed using a Pitot tube connected to a pressure-measuring instrument that converts pressure readings to velocity in meters per second (m/s).

Pitot tube setup and quadrant measurement

- Assemble the tripod or measurement frame at the test location, positioned to measure velocity at the four quadrants of the fan discharge face as specified by AAMA 501.1-17.
- Configure the measurement instrument to display velocity in meters per second (m/s).
- Connect the Pitot tube to the measurement instrument using the connecting tubes provided. Ensure all connections are secure to prevent air leakage.
- Zero the measurement instrument before beginning calibration to account for atmospheric pressure variations at the test site.
- Secure the Pitot tube firmly to the measurement frame, ensuring it will not shift during the measurements.
- Position the Pitot tube at the first quadrant measurement point as specified by AAMA 501.1-17.
- Orient the Pitot tube perpendicular to the fan discharge face using angle guides and bubble levels. The tube must point directly at the fan outlet, not at an angle (see Photo 7 on page 12.)
- Pitot tube orientation is a common source of measurement error. Even small angular shifts produce significantly inaccurate velocity readings. Verify alignment at each quadrant measurement point before recording data.

Fan calibration and velocity measurement

Fan calibration is the process of measuring airflow velocity at the four specified quadrant points and confirming that the fan produces the dynamic pressure required by AAMA 501.1-17. This is the single most important step in the entire testing procedure. Without proper calibration, test results are invalid.

Test pressure and equivalent wind velocity

AAMA 501.1-17 specifies standard test pressures and their equivalent wind velocities. Table 1 shows the relationship between pressure and velocity for industry-standard test conditions.

Table 1: Wind velocity vs. Equivalent industry standard test pressure (AAMA 501.1-17, Section 5.2)

Test Pressure	Equivalent Wind Velocity
300 Pa (6.24 psf)	22.1 m/s (50 mph)
380 Pa (8.00 psf)	24.9 m/s (56 mph)
480 Pa (10.00 psf)	28.0 m/s (63 mph)
580 Pa (12.00 psf)	30.8 m/s (69 mph)
720 Pa (15.00 psf)	34.3 m/s (77 mph)

Select the test pressure appropriate for the project requirements. The fan throttle must be adjusted to achieve the equivalent wind velocity corresponding to the specified test pressure.

Measuring velocity at each quadrant

- Activate the fan and allow it to reach steady-state operation
- Verify that the velocity instrument readings are stable. Minor variations are normal (e.g. +/- 1.1 m/s); larger fluctuations indicate turbulent flow or equipment issues.
- Record the velocity at each of the four quadrant points. Using video recording, identify the maximum velocity occurring within a one-minute duration for each quadrant (see Photo 8 on page 12).
- Turn off the fan between measurements at each quadrant to allow readings to stabilize.

Velocity-to-pressure conversion

Once velocity measurements are recorded in all four quadrants, convert these readings to equivalent velocity pressure and verify that the velocity aligns with the test pressure.

Convert metric to imperial units

Velocity (m/s) × 2.23693 = Velocity (mph)

Calculate equivalent velocity pressure

Using the formula specified by AAMA 501.1-17:

$$P = 0.00256 \times V^2$$

P = velocity pressure in pounds per square foot (psf)
V = velocity in mph

Calculate the mean velocity and standard deviation of velocity readings from all four quadrant points. Verify that all measurements fall within the tolerance of +/- 1.1 m/s (+/- 2.5 mph) specified by AAMA 501.1-17. If all points are within

Left: A large turbo-prop-style fan, commonly used by dedicated testing companies, would typically be mounted to telehandler-style mobile forklifts.

PHOTO COURTESY
SIMPSON GUMPERTZ &
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Top left - Photo 7: The Pitot tube should be perpendicular to the fan discharge face, using angle guides and bubble levels. The tube must point directly at the fan outlet, not at an angle.

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Bottom left - Photo 8: The velocity at each of the four quadrant points should be recorded. Video recording can identify the maximum velocity occurring within a one-minute duration for each quadrant.

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tolerance, calibration is complete. If any measurement falls outside the tolerance band, the fan speed must be recalibrated before testing.

AAMA 501.1-17 test parameters

Once calibration is complete and confirmed to meet standard requirements, the following test parameters apply per AAMA 501.1-17:

- **Test duration**—Testing must continue for a minimum of 15 minutes. If the equipment stops at any point during the test (e.g. the fan runs out of fuel), the test must restart and run continuously again for 15 minutes.
- **Water application rate**—Water must be applied at 3.4 L/m²·min (5 gal/ft²·h) measured at the face of the specimen. This is typically provided by a spray rack, which must also be calibrated in accordance with AAMA 501.1-17.

- **Test observation**—Continuously observe the specimen for signs of water penetration. Document the location, time of occurrence, and severity of any leakage observed during the 15-minute test period.
- **Test area coverage**—The effective test area per fan position is determined by the propeller diameter. For larger surfaces, reposition the fan on a square grid with spacing equal to two times the propeller diameter, covering the entire surface to be tested per AAMA 501.1-17.

AAMA 501.1-17 defines unacceptable water penetration as the occurrence of any of the following conditions. If it visibly appears beyond a plane parallel to the glazing (the vertical plane) intersecting the innermost projection of the test specimen, not including interior trim and hardware, per ASTM E331, *Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference*. Additionally, water penetrating through a perimeter detail and not contained within drained flashing, gutters, and sills incorporated in the mockup installation constitutes a failure.

Water accumulation on interior members of the system is allowed up to the specified limits: 15 mL (0.5 oz) maximum for individual locations, and cumulative totals not exceeding 15 mL (0.5 oz) for specimens ≤ 23 m² (250 sf) (prorated for larger specimens).

If any water leakage is observed that bypasses the building's intended drainage and containment systems, the assembly should be considered to have failed.

While AAMA 501.1-17 permits minor water accumulation within prescribed limits, water that penetrates beyond the designed drainage paths compromises the assembly's intended water management strategy. The goal of any water penetration test is zero uncontrolled water leakage.

Forthcoming AAMA 501.1 field-testing standard

Although AAMA 501.1-17 is commonly used in the field, it was originally developed as a laboratory test method and does not fully address the challenges of field testing. The FGIA task groups and committees are currently



updating the lab version of AAMA 501.1 and developing a separate field version, with both standards anticipated for publication in late 2026. The new standard is intended to address limitations in the current version of AAMA 501.1-17 as they relate to field testing and to provide more comprehensive guidance for implementing dynamic pressure water penetration testing under real-world field conditions. Here is a summary of the pertinent changes and guidance that will likely be in the forthcoming field-testing standard below.

- **Products in/out of scope**—The field standard will identify which fenestration systems can or cannot be tested under the field standard. Products certified under the North American Fenestration Standard (NAFS) are unlikely to be included in the new field standard.
- **Field preparation**—The field standard will provide specific guidance on the installation progress of adjacent materials around the test sample. In general, exterior cladding, rainscreens, and associated components, including the perimeter sealants, should be installed adjacent to the test sample. The standard also guides how to isolate fenestration systems when testing the air and vapor barrier under this standard.
- **Wind speed calibration requirements**—The field standard will provide additional calibration



guidance under field conditions and increases the allowance for variability in the wind speed. The field standard will also allow for a reduction in the maximum wind speed if the desired wind speed cannot be achieved in the field.

- **Recalibration frequency**—The frequency of recalibration remains unchanged in the field standard (e.g. minimum once every six months). The author's opinion is that the fan should be recalibrated before each test, as field testing conditions can significantly affect the equipment's accuracy.

When published, AAMA 501.1 will provide practitioners with more definitive guidance for field dynamic fan testing and will help improve the reliability and defensibility of test results.

Conclusion: Add another tool

Variations in construction practices and site conditions can influence how systems ultimately perform in the field. Accordingly, field testing remains an essential validation tool, delivering objective evidence that assemblies achieve their intended performance outcomes. Those most familiar with nozzle (AAMA 501.2) and chamber (ASTM E1105) testing should consider adding dynamic fan (AAMA 501.1) testing to their toolbox as another means of ensuring the building will be watertight and last a lifetime. 🌈

Left: Testing under AAMA 501.2, *Quality Assurance and Water Field Check of Installed Storefronts, Curtain Walls and Sloped Glazing Systems*, makes use of a nozzle.

PHOTO COURTESY SIMPSON GUMPERTZ & HEGER'S (SGH)

Right: In some cases, AAMA 501.1 testing may also be used as an alternative to ASTM E1105, *Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference*, when chamber installation is impractical, disruptive, or cost-prohibitive.

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additional information

AUTHORS



Landon Wade is an associate project consultant with Simpson Gumpertz & Heger's (SGH) building technology division. He performs enclosure consulting and field testing, specializing in AAMA 501.1 dynamic water penetration testing and glazing system evaluations. He can be reached at lgwade@sgh.com.



Luke Niezelski, P.E., is a senior project manager with Simpson Gumpertz & Heger's (SGH) building technology division. He specializes in building enclosure investigation, design, field testing, and construction administration for historic and contemporary projects. He can be reached at laniezelski@sgh.com.



Christopher Grey is a principal in Simpson Gumpertz & Heger's (SGH) building technology division in Boston, Mass. He specializes in building enclosure consulting, energy performance analysis, performance testing, and the design of unitized and prefabricated enclosure systems. He is a contributing member of the FGIA/AAMA, serving on several standard task groups. He can be reached at cngrey@sgh.com.

KEY TAKEAWAYS

Dynamic fan testing provides a practical way to evaluate the water-penetration resistance of a facade under simulated wind-driven rain. It can be used on mockups, completed assemblies, or existing buildings to verify performance and identify leak paths across curtain walls, storefronts, windows, and doors. Reliable results depend on correct setup, fan calibration, water application, test-pressure selection, and documentation. AAMA 501.1 testing complements—not universally replaces—other methods such as ASTM E1105 chamber testing and AAMA 501.2 nozzle testing. The forthcoming field-testing standard is expected to provide clearer guidance for on-site application.

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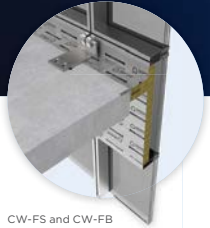


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Drawing the Line on Wall Flashing

Identifying Gaps in Current Practice

By Robert Bateman,
NCARB
PHOTOS AND DIAGRAMS
BY ROBERT BATEMAN

When waterproofing flashings are absent from buildings, there is a high risk of leaks. Water intrusion accounts for more than 70 percent of construction litigation.¹ Delays, callbacks, and change orders can also result from omitting flashing details from the initial building design.

Sheet metal flashing has been included in construction for more than 100 years. Galvanized sheet metal (GSM) used as flashing has become a proven commodity—one so common that

important characteristics for its use are missing in construction drawings, specifications, and industry references. The purpose of this article is to focus on GSM for wall-framed buildings.

Sheet metal flashing has been consistently used as a transition material between wall flashings and contemporary and traditional concealed drainage-plane water-resistant barriers (WRBs) behind claddings such as stucco, siding, and various wall cladding panel systems.



Sheet metal flashing is also used to transition window and door openings to the various WRBs available on the wall.

Current practice, despite drawbacks

The construction industry and design professions have not kept pace with documented code revisions, traditional designs, flashing details, and specifications used in current practice.

This article (the first of two) will address galvanized sheet metal problems observed over many years in conjunction with wood and metal-framed low-rise buildings in the Western U.S. Sheet metal flashing detailing in today's construction industry diverges in four ways from potential best practice:

- **Non-compliance with building codes**—Incomplete flashing details on drawings do not conform to current applicable building codes.
- **Absent construction details**—Lack of flashing detailing training for architectural schools or design office apprentices.
- **Lack of industry references**—Galvanized sheet metal flashing does not have a dedicated industry reference for wall-framed, low-rise buildings. They are typically found with residential and light commercial construction.
- **Incomplete specifications**—Current specification templates are generic, lack wall-specific flashings, and have not kept pace with available flashing material and fabrications.



These issues are important, especially now, as we examine current practices and the opportunities that have been passed over in building design, detailing, fabrication, and installation.

Building code requirements

Building codes requiring roof and wall flashings have evolved in recent years. There are additional wall flashing requirements for wall openings, such as windows, doors, and wall penetrations. Two applicable national building codes include the *International Building Code (IBC)*^{2A} and the *International Residential Code (IRC)*.^{2B} Wall flashings are addressed in the code in three ways: specific building locations, required details on drawings submitted for permit, and newly approved flashing materials.

The importance of flashings is reemphasized with recent inclusions in the building codes. New

These photos show the fabrication and installation of galvanized sheet-metal wall flashing, including mechanical fastening and soldering of lapped joints for waterproofing.

Figure 1

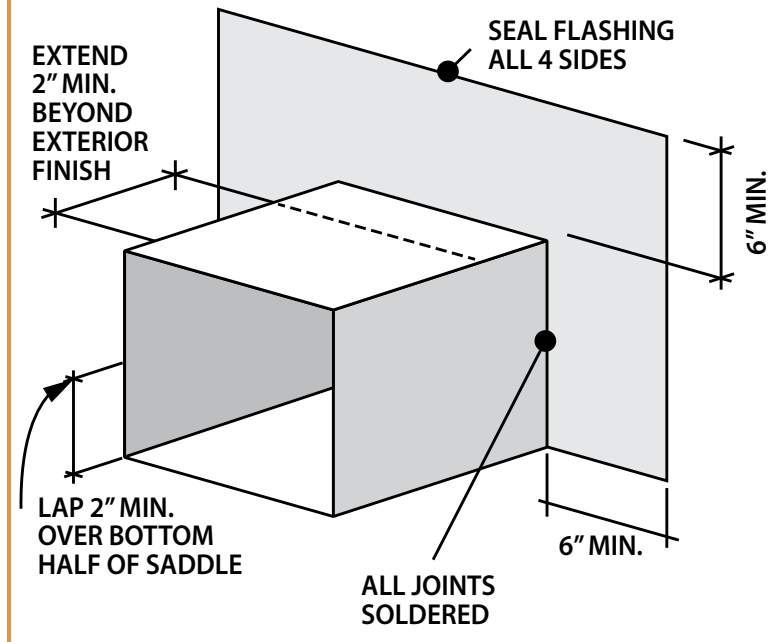


Figure 1: An intersecting wall saddle flashing detail.

installation requirements appeared in the 2021 IRC for window/door flashing, Sec. R703.4.2 and for water-resistive barriers, Sec. R703.7.3.

Flashing locations

Building codes list some wall locations that require flashings. Sheet metal flashings are generally required by building codes at common transitions and termination locations of walls. The 2021 IRC Sec. R703.4 code excerpt indicates specific locations for wall flashing installations. These locations include wall flashings at windows and doors, above projecting wood trim, weep screeds, and decks attached to wood-frame construction. The IBC also identifies specific locations for flashings:

2021 IBC Section 107.2.4 Exterior Wall Envelope. "...provide details... including flashing, intersections with dissimilar materials, corners, end details, control joints intersections at roof, eaves, or parapets, means of drainage, water-resistive barrier and details around openings."

Flashing details required on permit drawings

Critical waterproofing details required by building codes must be included on construction drawings submitted for a building permit. As noted above and below in the code excerpts, the flashing details are required on plans:

2021 IBC Section 107.2.4 Exterior Wall Envelope. "The Construction Documents shall provide details of the exterior wall envelope ..."

2021 IRC Section R106.1.1 Information on Construction Documents. "... Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed and show in detail that it will conform to the provisions of this code."

Code-approved flashing materials

Sheet metal is the default corrosion-resistant flashing material specified by the codes, with a minimum thickness of 26 gauge, equal to 0.55 mm (0.0179 in.) Galvanized sheet metal is the historically common, practical, and affordable sheet metal used for roof and wall flashings to comply with building codes.

In addition to the continued use of traditional sheet metal flashings, new weatherproofing materials have been introduced to the construction industry since the 1980s. These include self-adhering flashings (SAF) and liquid-applied flashing (LAF), as well as the introduction of newer water-resistive barriers (WRB) and air barriers (AB) for framed wood and light-gauge steel residential and low-rise commercial buildings.

Regardless of code requirements, waterproofing details are often absent in architectural practice. And it is common to find incomplete drawings and specifications with flashing details or requirements omitted.

Attention to flashings is not highly emphasized in the training or practice of building department plan reviewers and field inspectors, where life-safety issues take priority. Even though flashing is emphasized in the building codes, plans without flashing details are often approved, even though the details are absent from the drawings. Part two of this article will address this. As a building is being built, the locations requiring attention are often overlooked in specifying effective flashing.

Construction drawings and details

The subject of building technology, including building waterproofing, is not emphasized in most architectural schools; therefore, the requirement and need for flashing are notably absent. The technical aspects of architectural training have been assumed to be learned in the



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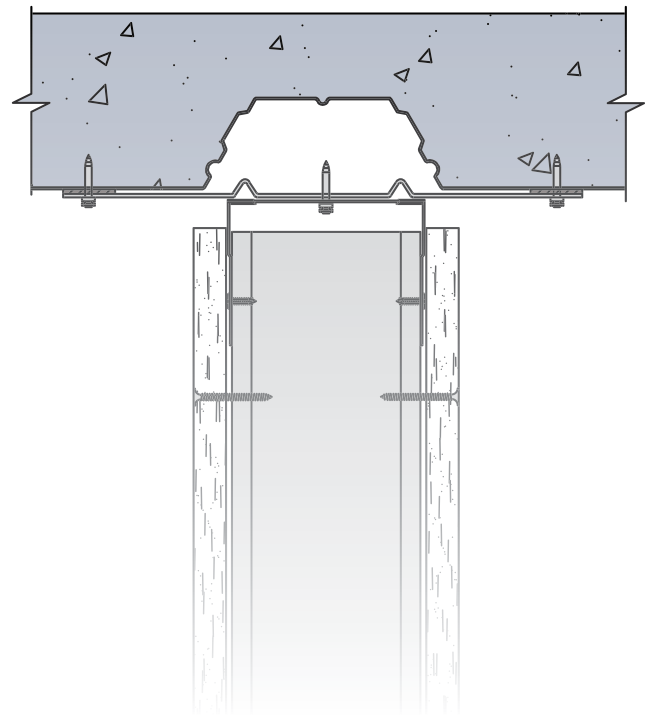
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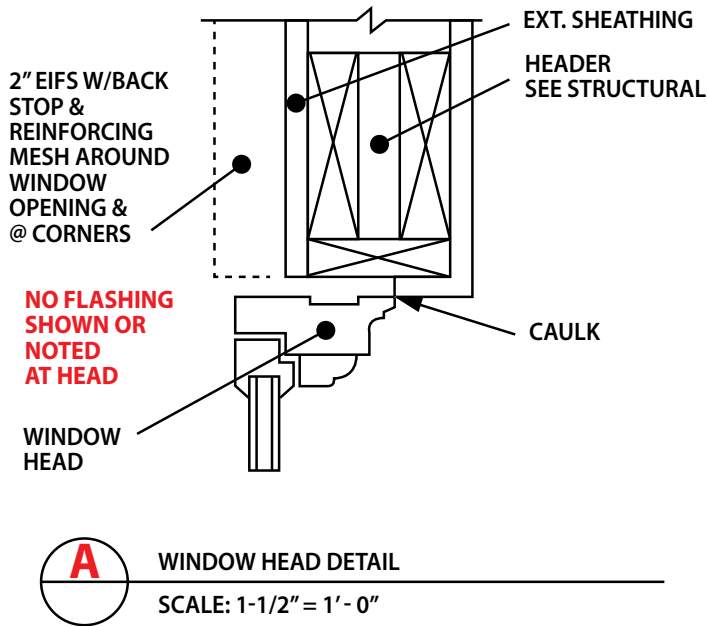


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Figure A



notes, dimensions are not included (see Figure C on page 21).

Sometimes, an over-reliance on inflated detail notes leads to components not being illustrated. See Figure D on page 21 for the transition of flashings to a WRB.

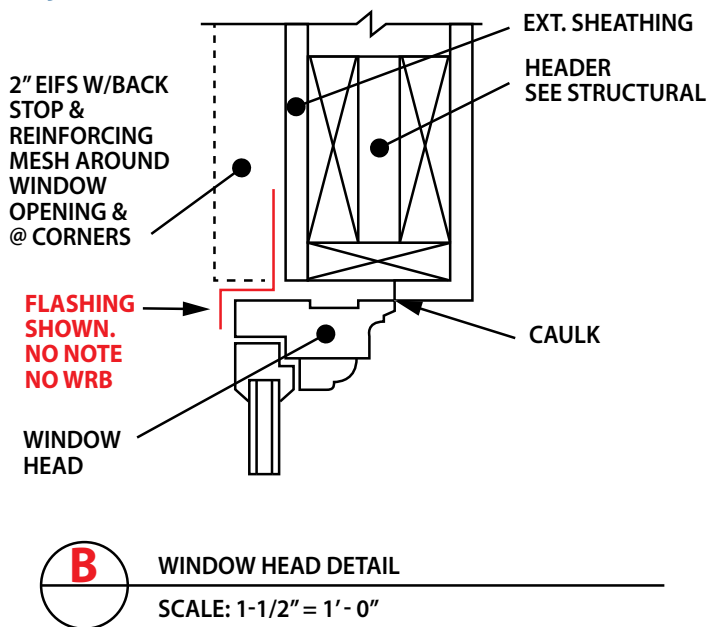
Architectural details are expected to show buildings and building assemblies in standard graphic representation, including vertical and horizontal section views, such as head, jamb, and sill for window openings. Figures A to D are representative examples of various head details that could be found on many construction drawings. However, it is rare to find 3D corner details on construction drawings. Details in 3D may appear in a fabricator's shop drawing submittals if required by the project specifications. Current practice for bidding and shop drawing submittals has sheet metal subcontractors bid only on what is shown and noted in the details. Or, a bidder will choose the available options that best align with their intended scope of work when the construction documents are not otherwise clear. This can have unintended consequences, such as increased requests for information (RFIs), change orders, and changes to the budget's cost and scope.

Industry references

Sheet metal flashing for buildings is known in the trade as architectural sheet metal. The most widely used industry references for sheet metal flashings are publications³ from the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA). Their primary reference is the Architectural Sheet Metal Manual (ASMM), published in its present format since 1965. It is the most referenced publication in project specifications, and its two most notable benefits are the numbering of individual details and the presentation of 3D sheet metal drawings, often with sheet metal shading to enhance graphic understanding (similar to Figure 1 on page 18). However, most SMACNA details do not include 3D views of flashing corners and terminations. The SMACNA details show completed multi-piece assemblies and not the fabrication of separate flashing pieces.

The SMACNA reference for residential construction is the Residential Sheet Metal

Figure B



Figures A to D (see Figures C and D on page 21) show various examples of flashing details lacking wall flashings noted or shown. Note: there is no indication of sloping the top of the head flashings for drainage.

design office from field-experienced staff. However, typical construction drawings often omit showing flashings in wall details.

Examples of typical details with absent flashings are shown in Figures A to D. Details with the note "Flashing by Others" are not acceptable today (Figure A). Or, when flashing is shown graphically, the detail does not include drawing notes identifying flashings (Figure B). When the details with flashings are shown with drawing

Guidelines (RSMG) published in 2001. An example of a freehand rendering of a sheet-metal flashing detail from RSMG (Figure 5-1) is shown in Figure 1.

Limitations of SMACNA references

Even though these two SMACNA references are useful and ubiquitous, they have a few limitations. First, SMACNA emphasizes roofing sheet metal, so its content predominates with masonry flashings and roofing counter flashings. Second, since its inception, the ASMM has had a U.S. East Coast bias in its masonry wall construction features. Only one of the 20-plus pages of flashing details in Chapter 4 of ASMM contains a framed wall flashing example. Third, ASMM tends to show complex and ornate sheet metal configurations, such as spires, trash chutes, and cornices, to demonstrate sheet metal's versatility, but does not show everyday, mundane wall flashing configurations used for practical waterproofing details. These critical details impact performance and are as important as any complex, sophisticated flashing and waterproofing assembly. Fourth, it lacks discussion of contemporary sheet metal fabrication practices, such as spot welding, blind riveting, and coordinating with other flexible flashings, e.g. SAF and LAF.

Project specifications often refer to SMACNA's ASMM in general terms, e.g. "comply with SMACNA." However, the ASMM may offer more options than the project specifications or drawings present. Typical specifications do not acknowledge or select available specific SMACNA details (see Figure 2 on page 22). The ASMM contains embedded options that range in performance from simple lapped and sealant seams to mechanically fastened and soldered watertight seams. Unless a specific SMACNA option is identified in the project drawings or specifications, the sheet metal bidder may select any available option for installation and still meet the minimum specification requirements. The ASMM encourages specific selection, stating, "direct reference to this manual [ASMM] by figure or detail number is encouraged." Most specifications do not reference specific SMACNA options (see Figure 2 on page 22). But even so, not all detail options now available, reflecting contemporary practices, are included by SMACNA (see Figure 3 on page 23).

Figure C

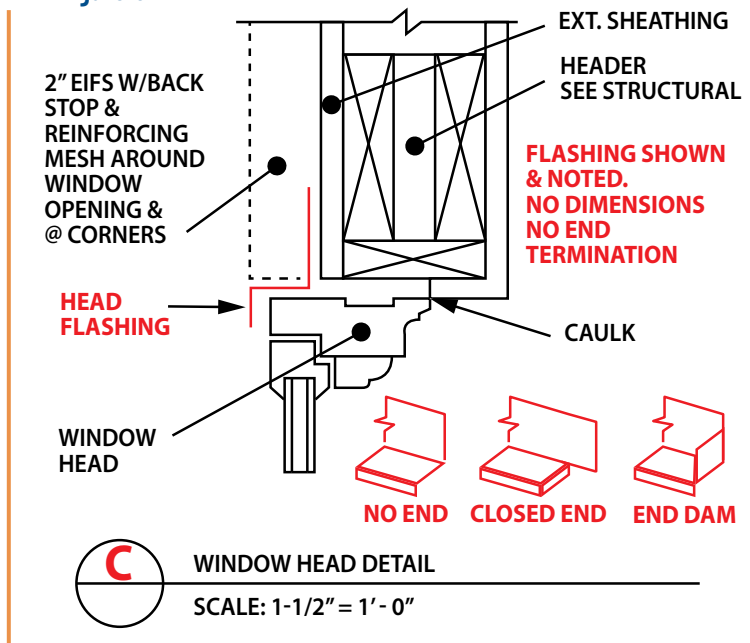
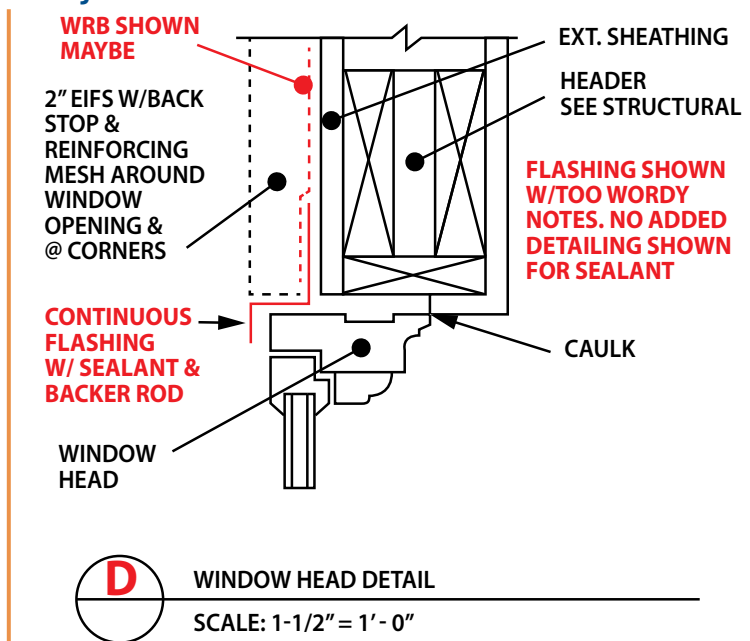


Figure D



What has been lacking is an updated industry reference for designers and specifiers that focuses on wood- and metal-stud wall framing with galvanized sheet metal (see part two of this article). This type of construction has been predominantly used in the Western U.S. since the 1920s. Framed walls remain the most common structural system for residential and light commercial buildings after World War II.

SMACNA briefly covers the mechanical fastening of simple lapped galvanized sheet-metal joints using blind rivets or spot welding.

Figure 2

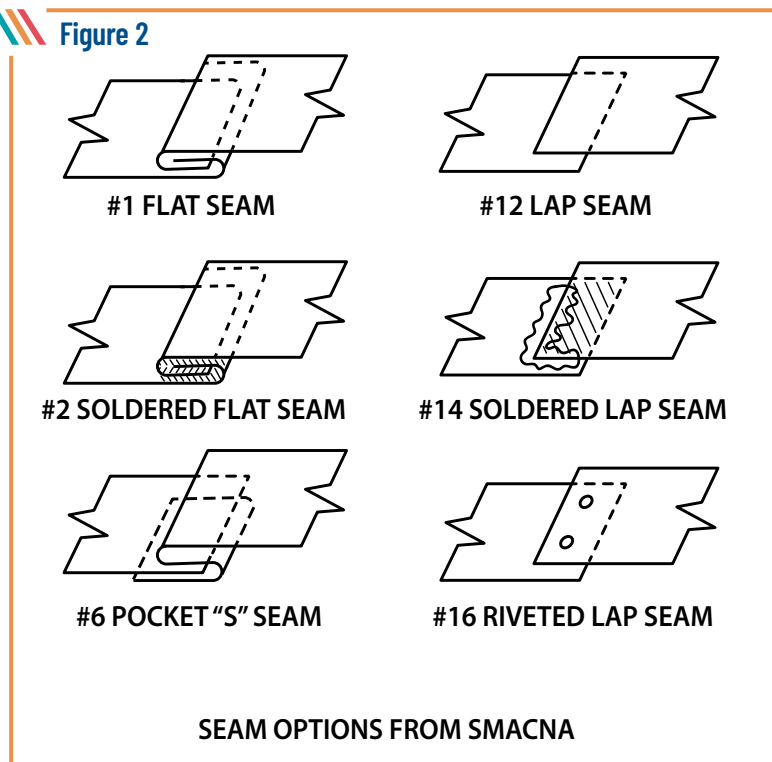


Figure 2: Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) seam options in the Architectural Sheet Metal Manual (ASMM) can be expected to vary in performance and quality.

Blind rivets

SMACNA does not address fastening sheet metal by rivets in any depth, except stating, "Joints that are locked and soldered do not require rivets for additional strength. Joints that are lapped and soldered require rivets to strengthen the seam." Most wall flashings do not use locked seam joints, so mechanical fastening joints are the recommended best practice. The fastening process with blind ("pop") rivets (a common mechanical fastening method), followed by soldering, is not covered by SMACNA.

The blind riveting process starts with the layout of holes to be punched or drilled through lapped sheet metal, with the hole size dependent on rivet diameter, typically 3.2 mm ($1/8$ in.) Basic riveting starts with clamped pieces secured flat and tight, then a hole is drilled through both sheets with a rivet inserted. Field-drilling, where the sheet metal piece is set directly on the wall substrate, and holes are then drilled, should not be performed to avoid puncturing any pre-installed underlying flexible flashing or WRB. The blind rivet has a mandrel pin at one end that is inserted into a rivet gun. The mandrel is drawn tight and snaps inside the rivet with release. The rivet securely fastens the two sheet-metal pieces. The protruding rivet head should not penetrate any underlying flashing membrane

or WRB. Performance is affected by the thickness of the metal pieces, the rivet's depth, and the selected diameter.

Spot welding laps

Spot welding is a type of resistance welding in which thin sheets of lapped metal are fused in a spot by pulsed electrical resistance. Spot welding with soldering is not noted in any SMACNA detail, and the combination alone is not watertight. It is a mechanical fastening process in which lapped sheet-metal edges are held together under pressure by a machine using two opposing electrodes, then welded with a burst of electric current. The variables in spot welding performance include weld time, electrode tip size, electric current, and metal thickness. Spot welding can occur in a shop or on-site with portable equipment.

Soldering seams

Watertight joints in lapped sheet metal can be achieved by soldering between the laps. Soldering is only superficially mentioned by SMACNA. In today's practice, after joints are fastened with blind rivets or spot welding, the entire lapped joint is fully sweat-soldered. Galvanized sheet-metal flashings' joints are waterproofed at the seams by soldering. Soldering must fill the lapped area and the edges. Soldering alone is not relied upon for structural strength without mechanical fastening of rivets or spot welding. Performance is affected by flux preparation, solder temperature, the width and depth of the metal lap, and the extent of fully sweated solder.

The SMACNA manuals are geared more toward sheet metal shop practice and management than design, layout, and detailing.

Guide specification templates

Specifications identify the design and construction requirements, with expected coordination with the construction drawings. Drawings and specifications are complementary, meaning they have equal precedence. Unless a different order of precedence is agreed to or specified by the policies of certain owners, e.g. some governmental agencies, both specifications and drawings are required; written specification descriptions will not take the place of omitted details on drawings.

In general, designers use only a few resources to develop sheet metal flashing specifications

for a specific project, including a similar previous project, a specification consultant, a client-provided specification, and proprietary specification guides.

The accepted specification format from all sources of specification content is based on the Construction Specifications Institute's⁴ (CSI) MasterFormat section 07 62 00—Sheet Metal Flashing and Trim.

CSI is the design professions and construction industry's predominant resource for building construction specification formatting.

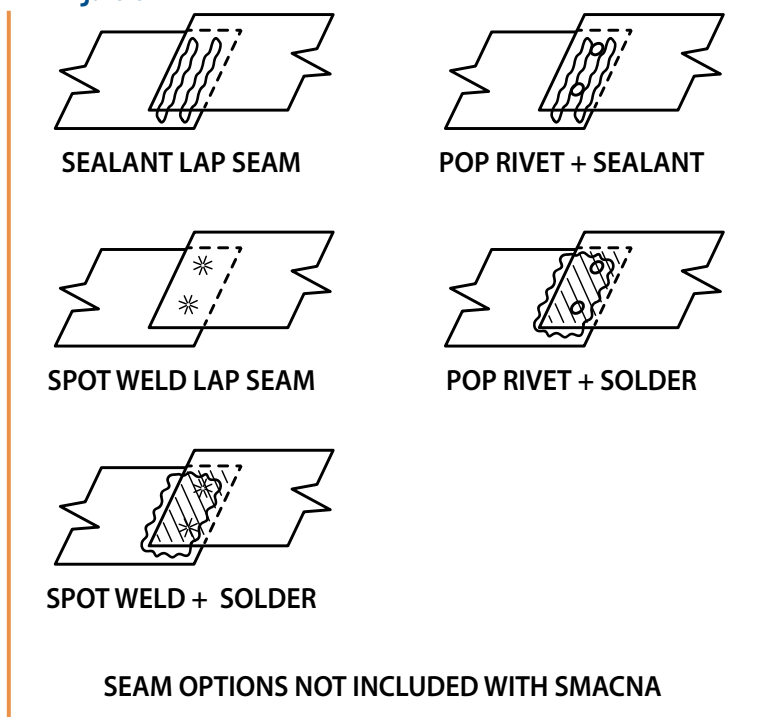
Project specification development usually occurs in design offices, where designers either reference a similar past project or start by editing a guide specification template. A specification template should be modified with additions or deletions to suit the current project and current practices. Guide template specs often become outdated and incomplete, especially regarding wall flashings. Many boilerplate provisions become reused without relevance to the current project.

The typical guide template for today's 07 62 00 spec has limitations and omissions in its scope, failing to address newer methods for detailing and installing architectural sheet metal flashings. Typical 07 62 00 specs, such as SMACNA, focus on roof flashings and sheet metal accessories. There is little separate attention to wall flashings on framed buildings as a format section in typical sheet metal specifications.

Therefore, it is not surprising to find sheet metal installers ignoring vague and outdated project specifications. Bidders encountering missing or incomplete details will only bid on what is shown and noted on the drawings. Including bids for absent flashings risks non-competitive bids (too high to win a contract). The successful low bidder can later submit change orders for any added or missing flashings. It is no longer acceptable for specification resources to include omnibus specifications that broadly require the work to be completed to the satisfaction of the architect, without specifying whether all necessary elements have been identified, worked out by the designer, and documented.

The following items are excerpts from a typical 07 62 00 example guide specification, followed by the author's commentary:

Figure 3



System Description: The requirements shown by details are intended to establish basic dimensions, profiles and sightlines. Within these limitations, the Contractor will be responsible for the design of sheet metal flashing and trim assemblies and make whatever modifications of and additions to the details as may be required to prevent water and air penetration.

Author's commentary: This is an example of a rather vague specification transferring design decisions from the designer to the contractor. It is also a retrograde omnibus specification that imposes an overall burden on the contractor to complete the installation, without requiring the designer to spell out a comprehensive scope of work and detailed specifications.

This broad language can result in, for example, the sheet metal installer submitting and installing a product that does not meet the intended design performance. Since galvanized sheet metal flashing is a commodity item, flashings are sourced from regional steel mills, stockpiled by metal distributors, and fabricated on demand in individual regionally based shops. There is no expectation of written instructions from the individual steel mills that produce galvanized sheet metal. Individual fabricators or local sheet metal shops may have their own accepted practices, but these likely vary and are not available during the project design phase.

Figure 3: These are the seam options available, but not included by the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).



These photos illustrate the field fabrication, mechanical fastening, and soldering of galvanized sheet-metal flashing components and seams.



differences vary from shop to shop and do not appear until shop drawings are submitted.

3.0 Installation General: *Install sheet metal flashing and trim to comply with performance requirements, SMACNA's "Architectural Sheet Metal Manual" or as indicated.*

Author's commentary: This is a general reference to an industry publication that offers several options. It is so vague that, if the specifications intend to support the general design intent but do not require specific ASMM details, there may be no available wall flashing detail in the ASMM for the building locations noted for flashing. Further, SMACNA does not classify its details by performance rating. The phrase "or as indicated" is currently found in most guide specification templates. The phrase "as indicated" is generally presumed to mean as shown on the drawings. If the drawing details are incomplete, however, this reference to a specification catch-all phrase becomes pointless.

3.0 Installation Riveting: *Install rivets for strength where needed for strength.*

Author's commentary: "Needed for strength" is a vague requirement. This phrase does not conform to CSI's style guide⁴ and could be interpreted as a performance specification, but without any test requirement. Generally, this corresponds to the extent of rivet requirements outlined in most guide specification templates.

These are just a few representative examples of specification sections that should be revised (refer to part two of this article). Galvanized sheet metal wall flashing should be treated in more detail and with more comprehensive specifications at present, with changes based on

Product consistency will not occur without specific details and specification requirements in the construction documents. Architects do not have access to documentation of individual shop practices during wall design unless project files were retained as references from a previous building project.

2.0 Products – Rivets: *High-strength aluminum or stainless-steel rivets suitable for metal being fastened where necessary for strength.*

Author's commentary: "Where necessary" leaves the decision up to the sheet metal installer's judgment. This phrase does not conform to CSI's style guide⁴ and provides an ambiguous direction with no qualitative requirements for measuring performance. These installation practices



the author's limited review of current practices. This current research has reviewed example specification templates and selected representative project manuals. Today's specification guides for section 07 62 00 exhibit a common repetition of spec format, product subjects covered, installation, and spec language.

Conclusion

Several metal types are used for flashings in building construction, including galvanized sheet metal, copper, stainless steel, zinc, and lead. Each metal material has its own differing features to account for in detailing, fabrication, and installation.

Building designers, due to a lack of teaching in school or training in the design office, are insufficiently knowledgeable about flashing detailing. This results in missing flashing details in construction documents. Secondly, when details are incomplete, the construction documents will not comply with building code permit submission requirements. Thirdly, no industry reference is available for sheet metal flashing in wall-framed buildings. Lastly, the current generic specification templates have not kept up with today's available flashing fabrications. Completed sheet metal flashing design and construction requires addressing these four factors.

The four factors of improved detailing, designer training, more options, and generic specifications for sheet metal flashing for framed wall buildings can converge to meet current best practices with attention to simple changes. With specific guidance

on the design and detailing of sheet metal flashings, architects, building designers, specifiers, fabricators, and quality control inspectors should be able to develop a comprehensive reference to better evaluate expected performance. With a dedicated sheet metal wall flashing reference, subcontractor bids will estimate the same scope of work and will not be left to select the least costly available SMACNA option.

The construction industry and design professions' use of computer modeling with building information modeling (BIM), computer-aided design (CAD), and 3D software offers opportunities not only to make shop drawings and fabrications more efficient, but also to increase the development and widespread use of 3D architectural detailing. 

NOTES

¹ See Aaron Seward, "When It Leaks, It Pours," *Architect Magazine*, June 6, 2011, architectmagazine.com/technology/when-it-leaks-it-pours_o

² Refer to International Code Council, (A) *International Building Code (IBC)*, 2021; and (B) *International Residential Code (IRC)*, 2021, iccsafe.org.

³ Read more at Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), (A) *Architectural Sheet Metal Manual (ASMM)*, 2012; and (B) *Residential Sheet Metal Guidelines (RSMG)*, 2001, smacna.org

⁴ See Construction Specifications Institute (CSI), *MasterFormat*, 2020; and *Construction Specifications Practice Guide* (Alexandria, Va.: Construction Specifications Institute, 2018), 41, csiresources.org.

additional information

AUTHOR



Robert Bateman, NCARB, is a licensed architect in California and a registered architect in Washington and Nevada. He has more than 35 years of experience practicing as a forensic consultant, investigating building leaks, developing construction repair details, and conducting construction document peer reviews for new projects. He has developed flashing sequence details for manufacturers' instructions for adhered-veneer and SAF for framed wall buildings. Besides contributing to the standards ASTM E2112 and E2266, he has written two guidebooks for window installations and stucco details, available at flashingdetails.com. He welcomes sheet metal flashing detail suggestions for a forthcoming sheet metal flashing guide and can be reached at jrobert.bateman@gmail.com.

MASTERFORMAT NO.

07 25 00-Weather Barriers
07 60 00-Flashing and Sheet Metal
07 62 00-Sheet Metal Flashing and Trim

UNIFORMAT NO.

B2010-Exterior Walls
B2020-Exterior Windows
B3010-Roof Coverings

KEYWORDS

Division 07	Sheet metal flashing
Building envelope	Waterproofing
Galvanized sheet metal	



Choosing Fluid-applied Roofing Over Tear-off Replacement

By Kathy Schoch

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PROTECTIVE AND MARINE

Roof performance is critical to protecting industrial and manufacturing facilities. A compromised roof can expose equipment, inventory, and interior environments to moisture, temperature fluctuations, and long-term structural damage, resulting in hours or days of downtime and costing valuable time and money. Traditionally, when roofs reached the end of their service life, full tear-off and replacement was considered the default solution. Today, that assumption is being challenged.

As facility owners want to reduce disruption, control costs, and extend asset life, fluid-applied roofing systems are emerging as an alternative to traditional replacement.

This shift is being driven by a simple realization: many industrial roofs are not failing structurally, they just are aging. Fluid-applied systems are designed specifically for maintenance, repair,

and operations (MRO), allowing facilities to restore performance and extend a roof's lifespan. Fluid-applied coatings are renewable by recoating every 10 to 20 years, deferring replacement without sacrificing protection.

Common roofing systems in industrial facilities

Industrial buildings commonly use roofing systems to cover large, low-slope areas while accommodating mechanical equipment and roof traffic. These systems often include:

- Metal roofing
- Single-ply membranes such as ethylene propylene diene monomer (EPDM), thermoplastic polyolefin (TPO), and polyvinyl chloride (PVC)
- Built-up roofing (BUR)
- Modified bitumen and granular cap sheets



- Spray polyurethane foam
- Concrete roof decks

While these systems vary in construction, they share a common challenge: long-term exposure to UV radiation, weathering, thermal cycling, and mechanical stress. Over time, vulnerability in seams, flashing, fasteners, and penetrations can compromise the roof's ability to protect the facility and its investments.

What is a fluid-applied roofing system?

Within the roofing industry, the terms roof coating and fluid-applied roofing system are sometimes used interchangeably, but they represent different approaches to roof maintenance and restoration. A roof coating may be used as a maintenance product or reflective surface treatment, while a fluid-applied roofing

system is designed as a more comprehensive restoration solution intended to extend the service life of an existing roof.

Fluid-applied roofing systems are installed directly over an existing roof after appropriate preparation and repairs by trained or authorized roofing contractors and may involve project specifications, pre-installation moisture surveys, substrate assessments, documented application procedures, and quality-control inspections.

Unlike tear-off replacement, fluid-applied roofing is a restoration strategy. After initial repairs, the existing roof is pressure-washed and cleaned; penetrations and transitions, such as HVAC units, stacks, and equipment, are sealed; and the coating system is applied by spray, squeegee, back-roll, or roller. Once cured, a properly specified and installed fluid-applied system forms a continuous, fully adhered protective layer that can help restore water-shedding performance, protect the roof from ultraviolet exposure, and extend service life.

The process makes fluid-applied roofing a viable option for facilities focused on long term asset preservation, offering a way to extend roof service life while reducing the disruption and expense associated with full replacement.

Project teams must also consider how a fluid-applied system affects applicable performance requirements since it becomes part of the existing roof assembly. The *International Building Code (IBC)* requires applicable Class A, B and C roof assemblies and roof coverings to be tested in accordance with ASTM E108 or UL 790 and requires roof coatings to comply with applicable fire-classification provisions.

Industry guidance from the Roof Coatings Manufacturers Association (RCMA) similarly directs project teams to verify applicable UL or FM requirements when coatings are installed over classified roof systems. Building owners and design professionals should therefore confirm that the proposed system maintains the required fire classification and complies with applicable code requirements.

Restoration vs. replacement

Both tear-off replacement and fluid-applied restoration can address aging roofs. However, the impact on operations, budgets, and long-term performance differs significantly, which is



Existing low-slope roof conditions prior to restoration.

why fluid-applied solutions are increasingly considered when existing roof conditions support restoration.

Market data underscores this shift. The global fluid-applied roofing market expanded from \$4.2 billion in 2021 to \$4.6 billion in 2022 and is forecast to nearly double by 2032, according to a Transparency Market Research study on the cool roof coatings market. In the United States, which accounts for roughly a quarter of global demand, growth has been driven by growing sustainability initiatives, energy-efficiency goals, and a broader shift toward extending existing assets rather than replacing them.

Operational impact: Minimizing risk to production

Removing existing roofing materials exposes the building interior and contents, generates debris, and increases the risk of weather-related damage or delays. For manufacturing environments, this means production interruptions, contamination concerns, and working around shutdown windows.

Fluid-applied roofing systems are installed with minimal to no demolition, allowing facilities to remain operational. Because the existing roof remains in place, the risk of exposing interior spaces during construction may be reduced, which is a significant advantage for facilities that require operational continuity.

Fluid-applied systems also offer job-site safety benefits by reducing the number of man-hours required to complete the project, avoiding heat welding and open flames, reducing contractor liability, and lowering overall risk. Any downtime may be limited to localized areas where wet insulation must be removed, minimizing disruption.



Structural load: A smarter choice for aging facilities

Adding or replacing roofing systems can increase a building's weight. In older facilities, this can cause structural evaluations, reinforcements, or design limitations, increasing project scope and cost.

Fluid-applied systems can add relatively little weight compared with some replacement or recovery options. This makes them appropriate for aging industrial buildings where structural modification is impractical or cost-prohibitive. However, project teams should confirm the existing roof assembly, the number of roof layers, and the structural capacity before proceeding.

Seamless protection: Addressing the root cause of leaks

Most roof leaks are caused by damage (punctures) at seams, laps, fasteners, and penetrations. Traditional roofing systems rely on mechanical joints that can be vulnerable to movement and weathering over time.

Fluid-applied systems can reduce the number of laps and exposed seams found in many conventional roof assemblies. Their performance, however, depends on substrate preparation, reinforcement where required, film thickness, detailing at penetrations and transitions, drainage, and installation quality. If the coating fully adheres to the roof surface and transitions, it can provide uniform waterproofing across the entire roof,



Previous repairs and existing roof conditions are reviewed before a fluid-applied restoration.



including complex areas such as pipe penetrations, pitch pockets, rooftop equipment curbs, parapet transitions, and other areas that have historically been difficult to protect with traditional materials.

From a performance standpoint, fluid-applied systems also add measurable protection. For example, while a typical TPO membrane may be 45–60 mils thick, a fluid-applied coating can add 22–40 mils of seamless film. One thing to note: coating thickness and membrane thickness are not directly equivalent measures of performance. With that in mind, the added fluid-applied layer can help restore and protect the existing membrane rather than requiring full replacement.

Extending roof life through temperature control

Industrial roofs are exposed to extreme temperature swings that accelerate material fatigue. Dark roof surfaces can reach very high temperatures in direct sunlight, placing constant stress on seams, flashing, and substrates.

Reflective fluid-applied coatings and roofing significantly reduce roof surface temperatures by reflecting solar energy. Keeping the roof closer to ambient temperature minimizes thermal movement, reduces stress on the roof, and slows long-term degradation. Over time, this temperature moderation can help extend roof service life.

For facilities with large non-air-conditioned areas, reflective coatings can also help reduce

heat gain and moderate interior temperatures, creating more comfortable working conditions.

Energy efficiency: A practical operational benefit

Lower roof temperatures can help protect roofing materials and can also reduce heat transfer into the building. In large industrial spaces with high internal heat loads, this can reduce cooling demand and stabilize interior conditions.

Highly reflective fluid-applied systems support energy-efficiency goals by reducing peak cooling loads and easing the burden on HVAC systems. While results vary by facility, the energy impact is more important as roof area and operating hours increase.

Moving from replacement to renewal

A main reason that facilities are shifting toward fluid-applied systems is their renewable lifecycle model. Tear-off replacement is a one-time solution that inevitably leads to another replacement cycle.

Some fluid-applied systems may be recoated at the end of their warranty or service period, subject to inspection, preparation, and manufacturer requirements. Restoring protection and extending performance without removal helps transform roofing from a recurring maintenance task into a manageable, long-term strategy that can lead to greater predictability and control over lifecycle costs. However, to

Areas of membrane separation are documented during the inspection process to help define necessary repairs before coating application.



A roof assessment helps determine whether the existing assembly can be restored rather than replaced.

achieve this, annual maintenance is important to the longevity of any roofing system.

It is also important to distinguish between the warranty for a fluid-applied roofing system and the warranty for the underlying roof assembly. Coverage can vary by manufacturer, existing roof type, system specifications, and project conditions, so owners should understand exactly which components and performance conditions are covered. With this in mind, if a warranty is renewable at the end of the initial warranty period, owners should consider how to continue protecting the existing roof asset without automatically moving into a tear-off and replacement cycle. Fluid-applied system warranties may also include requirements for contractor qualification, inspections, maintenance, and future recoating to remain eligible for renewal.

Environmental responsibility and waste reduction

Roof tear-offs generate construction waste that must be transported and disposed of, contributing to landfill use and environmental impact. According to the International Institute of Building Enclosure Consultants (IIBEC), by preserving the existing roof, fluid-applied systems reduce waste and eliminate disposal fees. Avoiding tear-off also supports sustainability and environmental, social, and governance (ESG) goals by lowering embodied carbon and extending the useful life of existing building assets.

Financial flexibility and cost control

From a cost perspective, fluid-applied roofing systems typically require less labor, shorter installation timelines, and fewer indirect costs associated with downtime. Disposal and restoration costs can also be lower than the cost of full replacement.



Additionally, fluid-applied roofing projects can be treated as maintenance rather than full roof replacement. Maintenance expenditures are often different from capital replacement in facility budgets and accounting, which can provide additional flexibility for some organizations. For facilities balancing performance needs with budget constraints, this distinction can be significant.

In manufacturing and processing environments, the cost of a re-roof often extends well beyond the roof itself. Interior protection, debris management, and extended downtime can significantly compound total project costs, making restoration an alternative when the underlying roof assembly remains sound.

When fluid-applied makes sense

Fluid-applied systems are not recommended based on the industry segment, but on the roof condition. The integrity of the deck, insulation, and existing membrane determines whether restoration is viable.

Moisture scans, typically performed by qualified third-party providers, help identify trapped (latent) moisture within the roof assembly and determine whether restoration is a viable option. Several scan methods are available, including infrared thermography, nuclear scanning, and capacitance testing. Each offers different strengths based on roof type, weather conditions, and the level of detail needed.

For large facilities, drone-based infrared thermography is increasingly used as a cost-effective way to cover wide roof areas quickly and identify suspect zones for targeted cut tests or follow-up investigation. As a general guideline, roofs with widespread wet insulation (typically



Left: Existing membrane seams and flashing details are evaluated to identify areas that may require repair work before restoration.

Right: Existing patches and repaired areas are reviewed to confirm compatibility with the planned restoration system.

25 percent or more) may not be good candidates for restoration.

When the underlying assembly is sound, fluid-applied systems allow facility owners to move forward with confidence.

Why fluid-applied roofing is a proven alternative

While full replacement remains necessary in cases of severe structural damage or extensive moisture intrusion, many industrial roofs may be candidates for restoration when the deck, insulation, existing membrane, drainage conditions, and flashing details are in suitable condition. A roof-condition assessment is necessary to determine whether restoration,

partial replacement, or full replacement is the appropriate solution.

By pairing diagnostic tools such as moisture scanning with modern fluid-applied technologies, facilities can make data-driven decisions that prioritize performance, safety, and long-term value. For these buildings, fluid-applied roofing is no longer just an alternative—it is a proven path forward, offering a lower-risk way to extend roof life, minimize disruption, improve energy performance, and manage costs over time.

Rather than treating roofing as a cycle of tear-off and replacement, fluid-applied systems support a more strategic approach to asset management, emphasizing renewal, resilience, and continuity of operations. 🌈



additional information

AUTHOR



Kathy Schoch has been in the roofing industry for 37 years with a wide breadth of sales and technical experience. Industry involvement includes active membership in the International Institute of Building Enclosure Consultants (IIBEC) and National Women in Roofing (NWIR). Her role as

national account manager at Sherwin-Williams includes working with national clients to introduce and develop sustainable roofing programs that extend the longevity of their assets. In addition, she works with her team to develop programs with roofing contractors with a national footprint.

KEY TAKEAWAYS

Fluid-applied roofing can restore aging industrial and commercial roofs without the cost, waste, downtime, and operational disruption of full replacement. Once the existing roof is repaired and properly prepared, the seamless coating can improve waterproofing, reflect solar heat, reduce thermal stress, and extend service life through future recoating.

Restoration is appropriate only when the roof deck, insulation, membrane, drainage, flashings, and moisture conditions are sound. Thorough condition assessments and moisture scans help teams determine whether targeted repair, fluid-applied restoration, or full replacement offers the best long-term value.

MASTERFORMAT NO.

07 56 00—Fluid-Applied Roofing

UNIFORMAT NO.

B30—Roofing
B3010—Roof Coverings

KEYWORDS

Division 07
Fluid-applied roofing
Industrial roof restoration
Moisture scanning
Roof lifecycle management
Sustainable roofing



Multi-hazard Envelopes

Engineered for Hurricane Zones, Applied Nationwide

By Karine Galla
PHOTOS COURTESY
STO CORP.

Between 2016 and 2025, the United States experienced 29 hurricanes or tropical storms across those hurricane seasons. The cumulative damage from these storms is estimated at \$820 billion.¹ These losses underscore the importance of rigorous building codes in High Velocity Hurricane Zones (HVHZ).

Historically, HVHZ designations applied primarily to the wind-exposed coastal regions of South Florida. Recently, however, a shift has occurred. There is evidence that architects, developers, and building owners are applying HVHZ-level systems and standards in regions far from coastlines to exceed baseline code requirements and improve overall envelope resilience in response to increasing severe weather risks.² While these assemblies are not intended to replace tornado or safe-room design governed by standards such as FEMA P-361, *Safe*

Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms, they can enhance the performance of the building envelope under extreme wind and impact conditions. These assemblies were designed to meet the Miami-Dade NOA and/or *Florida Building Code (FBC)* requirements, not the local building codes outside of Florida.

This trend reflects a strategic response to evolving climate patterns, rising expectations for resilience, and tightening insurance requirements. This article dives into how these robust systems work and why they are ideal for regions and zones far from the Florida coast.

What defines an HVHZ-rated facade assembly?

An HVHZ-rated facade assembly, whether a ventilated rainscreen, EIFS, stucco system, or



Prefabricated facade solutions combine factory-controlled manufacturing with high-performance cladding assemblies, helping buildings resist extreme wind pressures, water penetration, and impact events while accelerating construction timelines.

prefabricated panelized wall, must pass the industry's most demanding performance tests. These evaluations simulate the combined stresses building envelopes experience during extreme weather events and include:

- Large missile impact testing—A 4.1 kg (9 lb) 2x4 timber projectile is propelled at a speed of 15.24 m/s (50 fps)
- Cyclic pressure loading—The system is subjected to thousands of cycles of positive and negative wind pressure to simulate the “push-pull” effect of a sustained storm.
- Static and dynamic water penetration—High-velocity water is sprayed at the assembly while under extreme pressure to ensure no moisture breaches the air-and-water-resistive barrier (AWB).

Designing these resilient envelopes requires a holistic strategy that addresses extreme wind pressures, wind-driven rain, continuous water management, and debris impact.

Some key features of an HVHZ system include:

- Tested facade assemblies, including rainscreen, EIFS, and stucco systems.
- Fire-resistant wall assemblies evaluated under *FBC* protocols.
- Both field-applied and prefabricated facade solutions.

- Cladding designed to resist high winds, water intrusion, and windborne debris.

These systems are among the industry's most rigorously tested facade assemblies. Understanding where to use them is essential, and there are many places where they are considered beneficial.

Where and why these systems are used beyond Florida

HVHZ standards were born of hurricanes. However, high-velocity winds and driving rain are increasingly common in other types of extreme weather across the country. Here are a few examples:

Tornado Alley

States such as Oklahoma and Kansas increasingly experience “derechos,” long-duration, straight-line windstorms and microbursts that can exceed 161 km/h (100 mph), speeds once thought to be exclusive to the coast. HVHZ-rated systems provide a tested safety factor that standard rainscreens cannot match.

Wind damage is often associated with direct pressure on the facade. However, significant damage during high-wind events in the Midwest or Great Plains is frequently caused by negative pressure (suction) on the leeward side of the

Fiber cement rainscreen systems combine high-density fiber cement panels with engineered sub-construction, air and water resistive barrier (AWB), and optional continuous insulation (c.i.) to create a durable ventilated facade assembly. Independent testing demonstrates the system's ability to withstand debris impact and severe weather events.



building. These conditions can overlap with regions identified by the *International Building Code (IBC)* as Windborne Debris Regions (Zones 1–4), where impact resistance and attachment integrity become critical design considerations.

- Standard systems may see cladding panels “sucked” off the track.
- HVHZ systems are engineered with reinforced subframes and clips specifically designed to resist this suction, keeping the building’s “skin” intact.

By specifying HVHZ in these areas, engineers effectively remove the “weakest link” in the building envelope.

‘Wind-driven rain’ in the interior

In regions such as the Ohio Valley and the Northeast, sideways rain has become a common characteristic of summer storm seasons. Traditional masonry or siding assemblies without proper drainage planes become saturated during prolonged wind-driven rain events, increasing the risk of moisture intrusion and mold growth. Pressure-equalized facade assemblies, such as ventilated rainscreen systems, use a larger cavity behind the cladding to help balance air pressure and reduce the force driving water into the wall assembly. Drained EIFS systems manage moisture differently, incorporating a narrow

drainage space that allows incidental water to escape and dry before reaching the structural wall. While the mechanisms differ, both approaches are designed to improve moisture management and protect the integrity of the building envelope. Since the system is built to withstand hurricane-force water entry, it effectively manages a standard Midwestern thunderstorm with ample safety margins.

Wind-driven rain from supercell thunderstorms can force water into building envelopes. The pressure-equalized design of an HVHZ rainscreen ensures that even if water penetrates the outer cladding, the internal air gap neutralizes the pressure, allowing the water to drain harmlessly away.

Hail-prone regions

In a hail-prone region such as Colorado or Texas, an HVHZ rating provides substantial hail resistance. Systems capable of withstanding large-missile impact testing typically demonstrate substantial resistance to hail that can damage conventional siding systems. However, these assemblies intend to maintain the structural integrity of the building envelope and protect occupants during severe weather events. While facade systems designed for HVHZ performance can reduce the risk of catastrophic failure, aesthetic damage to exterior finishes may still

occur during significant hail, hurricane, or tropical storm events.

Beyond projectile resistance, the behavior of facade materials under extreme loading conditions also influences envelope resilience. Ductile, multi-component assemblies, such as ventilated rainscreens with flexible attachment mechanisms, can absorb and redistribute energy during debris impact or cyclic wind loading. In contrast, brittle cladding materials may crack or shatter under concentrated forces. Compartmentalized cavity design and reinforced substrates further enhance performance by maintaining attachment integrity and controlling pressure equalization during severe storm events.

The insurance factor

Insurance requirements are a major driver behind the adoption of HVHZ-level performance standards. With global natural disaster losses exceeding \$180 billion annually, insurance companies are seeking “verifiable comprehensive performance.”

Property owners in non-coastal areas are finding that complying with HVHZ standards can lead to significantly lower premiums. According to recent industry reports, every \$1 invested in meeting these high-performance codes can yield up to \$11 in long-term savings by reducing storm damage and maintenance costs.³ In some cases, lenders are making HVHZ-grade cladding a prerequisite for financing large-scale commercial developments to mitigate financial exposure.

Thermal efficiency and moisture management

Beyond wind resistance, the “over-engineering” beyond code minimums of HVHZ systems offers secondary benefits that are highly desirable in any climate.

- **The latent heat effect**—In hot climates, HVHZ-rated ventilated rainscreens allow moisture-laden air to vent to the outside before it can vaporize and trap latent heat within the wall. This reduces the cooling load on HVAC systems, enhancing energy efficiency by up to 10 percent.⁴
- **Freeze-thaw protection**—In colder climates, freeze-thaw cycles pose a major durability challenge. HVHZ-level assemblies incorporate advanced drainage and drying strategies that help maintain a drywall cavity, reducing the risk



of ice expansion that could damage cladding or substrate materials.

Passive cooling and ‘future-proofing’

Architects are increasingly adopting a “future-ready” design philosophy. Modern buildings today are built to last 50 to 75 years. Given the unpredictability of climate patterns over the next half-century, specifying an HVHZ system is seen as a form of “climate adaptation.” It provides a structural buffer against emerging climate hazards, such as more frequent flooding and extreme heat, which were not traditionally addressed in local building codes.⁵

The gold standard for durability

Looking toward the 2027 and 2030 code cycles, many experts believe the distinction between “coastal” and “inland” requirements will continue to blur. High-performance facade assemblies, once reserved for coastal areas, have become the baseline for structures to perform for decades in an increasingly volatile climate. Studies from the

Continuous insulation (c.i.) EIFS can be engineered to meet *Florida Building Code (FBC)* Level E impact requirements, delivering enhanced resistance to windborne debris while maintaining c.i., moisture protection, and design flexibility within a fully tested facade assembly.

National Institute of Building Sciences (NIBS) have found that every \$1 invested in hazard mitigation can yield up to \$6 or more in long-term savings through reduced damage, maintenance, and operational disruption.⁶

For specifiers, these systems illustrate how integrated envelope assemblies, tested under standards such as ASTM E1886, *Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials*, ASTM E1996, *Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes*, and Miami-Dade protocols, can provide a higher level of risk mitigation for projects exposed to severe wind, water, and impact events.

The migration of HVHZ-rated envelope systems from coastal regions to inland markets represents a broader evolution in facade design. By treating the building envelope as an integrated performance system rather than a simple exterior wall, architects and engineers can deliver structures capable of withstanding extreme wind, water intrusion, and impact events while improving long-term durability and resilience.

As climate pressures and performance expectations continue to evolve, envelope systems designed for the most demanding conditions are increasingly informing best

practices for resilient building design across the country. 

NOTES

¹See Becker, Beverly. "Understanding HVHZ: A Comprehensive Guide for Architects and Contractors." September 13, 2024.

²Read more at Erdman, Jonathan. "The Staggering Price of US Hurricanes Since 2016: Over \$800 Billion." May 29, 2025.

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additional information

AUTHOR



Karine Galla is director of product management for Sto Corp. She has more than 20 years of experience in product marketing in EIFS, stucco, air and moisture barriers, and other materials. She has a master's degree from the University of Lyon, France. She is multilingual and holds the

Association of the Wall and Ceiling Industry's (AWCI) EIFS Doing it Right and Building Envelope Doing it Right certifications, as well as the ISO Internal Lead Auditor certification from Georgia Tech.

KEY TAKEAWAYS

Modern HVHZ-rated facade assemblies—ventilated rainscreens, EIFS, stucco systems, and prefabricated panelized walls—are increasingly specified well beyond coastal hurricane zones to address tornadoes, wind-driven rain, and hail. These tested

systems give architects and building owners a verified safety margin against extreme wind, water intrusion, and debris impact, along with secondary gains in thermal efficiency, insurance cost, and long-term durability.

MASTERFORMAT NO.

07 24 00—Exterior Insulation and Finish Systems (EIFS)

07 42 00—Wall Panels

09 24 00—Cement Plastering

UNIFORMAT NO.

B20—Exterior Enclosure

KEYWORDS

Division 07, 09

Building envelope

High Velocity Hurricane Zones (HVHZ)

Multi-hazard design

Multi-stage sealing systems



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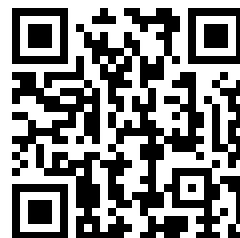
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The Future of Air Barriers

Embracing High-performance Materials for Sustainable Building Envelopes



By Frederick Torres,
EIT
PHOTO COURTESY IMETCO

In the world of specifications and architecture, what cannot be seen can make all the difference.

The importance of high-performance building envelopes has never been greater, and at their core lies the critical role of air barrier systems. Once an afterthought, air barriers are now essential in ensuring energy efficiency, moisture management, and occupant comfort in metal structures. As architects and builders push the boundaries of design with sleek metal panels, intricate facades, and expansive curtain walls, how air barrier systems integrate with metal construction is vital. This article explores the latest innovations, challenges, and best practices in crafting airtight, resilient metal architecture that stands out visually and excels in performance.

Why air barriers matter

Every building breathes, regardless of intent or design. Without proper control, unintended air leakage can compromise insulation, increase energy bills, introduce moisture problems, and even damage a building's structural integrity over time. Some key risks associated with air barrier systems and metal-based construction are

thermal bridging, moisture entrapment with condensation, and structural movement.

Since metal is highly conductive, heat can pass through the components, reducing the effectiveness of the installed insulation and air barrier system. This will cause excessive moisture buildup and induce corrosion, mold growth, and deterioration of insulation or sheathing. Structural movement caused by thermal expansion can potentially stress joints and seams, so it is important to integrate an air barrier system to prevent airtightness loss.

From the hot, humid southern states to the dry, frigid north, air barrier systems are tailored to tackle the environmental challenges of different regions head-on.

Building science has evolved; so have the materials used to manage airflow. Today's construction professionals have a toolkit of innovative options.

Fluid-applied barriers

These liquid membranes are ideal for complex architectural details. Once cured, they form a seamless barrier that blocks air infiltration. The barrier then serves as a primary control layer,



typically made of elastomeric coatings such as silyl-terminated polyether (STPE), acrylic, or silicone-based formulations. Since fluid-applied barriers are installed on substrates compatible with metal-framed curtain walls, application can often be coordinated with curtain wall installation and other enclosure activities, improving construction efficiency while helping maintain continuity of the air-barrier system.

Self-adhered membranes

In metal building design, where precise detailing and durable performance are critical, these systems offer controlled thickness and consistent installation over rigid substrates. Self-adhered membranes typically comprise modified bituminous sheets with polyethylene, rubberized asphalt with reinforcement layers, or non-bituminous, polymer-based membranes.

Spray foam insulation

Some formulas now include integrated air barrier agents, offering a powerful all-in-one insulation and air-sealing solution. Spray polyurethane foam (SPF) is typically applied directly onto the interior surfaces of metal walls and roofs and is a



This rendering shows a ventilated rainscreen system with a self-adhered air barrier membrane behind continuous stone wool insulation. Vented hat channels create an air cavity for drainage and drying, while cassette-style metal panels provide a durable exterior finish.

PHOTOS COURTESY IMETCO

Left: Building science has evolved; so have the materials used to manage airflow.

liquid that rapidly expands and cures into a rigid foam. Closed-cell SPF is often used in metal buildings due to its superior thermal resistance and structural rigidity. The foam adheres tightly to metal substrates, conforming to irregular surfaces and filling voids, enhancing thermal and air barrier integrity.

Increasingly, air-barrier systems are multifunctional, designed to control airflow while also providing water resistance, thermal insulation, and, in some assemblies, fire resistance. By combining multiple enclosure functions into fewer products and installation operations, these systems can reduce material waste, simplify installation, and potentially lower labor requirements.

Building green from the inside out

Sustainability is no longer just a buzzword—it is a mandate. Air barriers have become key players in meeting green building standards and reducing carbon emissions.

Energy efficiency

Properly installed air barriers lower heating and cooling demands. The Home Energy



Left: Within a rainscreen wall assembly, a liquid-applied air barrier works behind continuous insulation (c.i.), engineered framing, and metal cladding to help manage air and water while supporting the building's overall performance.

PHOTO COURTESY ANTHONY CHIARIZIO/IMETCO

Right: Complex facades often incorporate multiple exterior materials within a single design. A continuous liquid-applied air barrier can extend behind transitions from metal cladding to masonry and other facade types, helping maintain continuity across the entire building envelope.

PHOTO COURTESY ANTHONY CHIARIZIO/IMETCO

Rating System (HERS) index is often used to measure this, with lower scores reflecting greater efficiency.

Eco-friendly ingredients

Many manufacturers now use renewable and recycled materials, such as soy-based polymers and reclaimed plastics, to create breathable, biodegradable barriers.

Healthier spaces

Products with low volatile organic compound (VOC) emissions improve indoor air quality (IAQ) and align with green certification programs.

Smart systems for moisture management

Not all air barriers are created equal. "Breathable" or vapor-permeable barriers are essential in moisture-prone climates or sensitive construction zones. These systems allow moisture vapor to pass through while preventing air leakage, reducing the risk of mold, rot, and poor insulation performance.

Moisture management is critically important for metal architectural features, which are highly susceptible to corrosion, condensation damage, and structural degradation if not properly protected. Design experts are leveraging advanced technologies and digital tools to optimize the performance, integration, and longevity of air barrier systems.

For example, wireless sensors powered by the Internet of Things (IoT) are embedded in building envelopes to monitor moisture, humidity, and temperature in real time. These smart systems, often integrated with building management systems (BMS), can alert facility managers to

potential issues before they cause costly damage, bringing predictive maintenance to a whole new level. More specifically, real-time environmental monitoring includes detecting dew-point formations associated with condensation risks and pressure differentials to evaluate envelope tightness and air leakage.

BMS allow building managers to track air barrier performance over time through cloud-based dashboards that integrate anomaly detection algorithms to flag deviations and indicate potential failures. As a long-term asset, IoT data can be formulated into dynamic models to analyze performance. This is useful for warranty validation, lifecycle analysis, and planning upgrades/retrofits.

The road ahead: AI, carbon-negative design, and nanotech

The future of air barrier systems is looking smarter, greener, and more precise. Emerging technologies such as artificial intelligence (AI) and robotics will streamline application development and quality assurance. Some of these new technologies include:

- AI algorithms assist architects and engineers in designing air barrier systems that are highly effective and tailored to specific project needs.
- Machine learning models predict air leakage risks based on historical performance data, weather patterns, and material behavior.
- AI-driven simulation tools optimize air barrier placement to reduce thermal bridging and improve airtightness.
- Generative design uses AI to propose multiple layout configurations for the air barrier system, especially at complex junctions.

- Robots are being developed and deployed to automate and standardize the application of air barrier materials on metal substrates. Robotic sprayers or arms apply fluid-applied air barriers evenly over metal panels, ensuring consistent thickness and coverage, especially in high or hard-to-reach areas.
- Drones equipped with cameras and thermal sensors inspect building envelopes for continuity of air barrier membranes, identifying gaps or weak points post-installation.

Nanotechnology may also provide next-generation solutions at the molecular level, creating air barriers with unprecedented sensitivity and performance. Nanomaterials improve air and vapor impermeability through fine structures that block even microscopic air and moisture molecules. Using nanomaterials can prevent common defects in membrane punctures and produce anti-corrosion features to protect metal members. Advances in nanoscale hydrophobic coatings can repel water, preventing moisture buildup and extending the lifespan of metal substrates.

Meanwhile, the push for fully biodegradable, carbon-negative materials is gaining momentum, responding to rising global demand for sustainable construction. As building codes tighten and climate goals become more ambitious, air barrier systems are evolving into a high-tech powerhouse that is critical to the next generation of energy-efficient, resilient, and environmentally responsible architecture.



This is technically achieved by using bio-based materials and carbon-cutting insulation. Plant-based membranes, such as hempcrete, wood fiberboard, and cellulose, can absorb carbon dioxide during growth while providing high-performance barrier properties. The same goes for carbon-cutting insulation, which allows the carbon to sink in and creates airtight barriers.

An air barrier performs best when it is a continuous layer across the building envelope. Maintaining continuity at transitions, penetrations, openings, and material changes helps control unintended air movement and supports consistent performance throughout the wall assembly.

PHOTO COURTESY ANTHONY CHIARIZIO/IMETCO

The bottom line

The science of sealing a building is anything but simple. However, thanks to smarter materials, better technology, and a focus on sustainability, air barrier systems are quietly shaping the future of construction—one building envelope at a time. 🌱



additional information

AUTHOR



Frederick Torres, EIT, is an application engineer for Innovative Metals Company, Inc. (IMETCO).

KEY TAKEAWAYS

Air barriers are a critical control layer in metal building envelopes, helping limit air leakage, moisture accumulation, condensation, thermal bridging, corrosion, and energy loss. Successful systems require continuous detailing across seams, joints, penetrations, and transitions, while accommodating movement caused by temperature changes. Material selection should respond to climate, assembly design, and moisture-control needs. Fluid-applied, self-adhered, and spray foam systems each offer their own distinct benefits. Emerging tools such as thermal drones, IoT sensors, AI-driven modeling,

and predictive monitoring can strengthen installation quality, support maintenance planning, and meaningfully improve long-term enclosure resilience.

MASTERFORMAT NO.

07 27 00—Air Barriers

UNIFORMAT NO.

B20—Exterior Enclosure

KEYWORDS

Division 07
Air barriers
Envelope performance
Moisture management

Metal buildings
Thermal bridging
Vapor-permeable membranes

Room to Grow

Like any building material exposed to changing ambient conditions, tile flooring assemblies need room to move.

Movement joints (e.g. expansion, control, construction, etc.) relieve stress from thermal expansion in a floor or wall assembly and allow for differential movement between dissimilar materials. When proper movement joints are not provided, the flooring assembly can be damaged by the thermal expansion of the materials.

In the first project, marble floor tiles were used on an exterior covered porch and terrace of a building in Florida. The tiles were set in a mortar bed, and the narrow joints were filled with mortar. As the paving system expanded under full sun and in hot weather, individual tiles developed chips and spalls along their edges, where the stone was confined by the relatively hard mortar (Figure 1). Cyclical thermal expansion and contraction also caused cracking and the eventual failure of the mortar joints.

In the second project, red ceramic clay tiles were used as paving for an exterior terrace in the Midwest. The tiles were set in a mortar bed over a structural concrete floor slab, and the relatively wide joints were filled with mortar. Sealant was observed at occasional joints in the assembly, but these were not true expansion joints because they were not continuous through the assembly's depth and did not extend across the entire width or length of the paved area. During hot weather, the materials expanded, causing several portions of the paving assembly to buckle and heave (Figure 2). With the pavement confined at all edges by the building walls and the parapet, it had nowhere to go but up.

Guidelines for the design of expansion in paving systems are provided by the Tile Council of North America, Inc. (TCNA), the American National Standards Institute (ANSI), and ASTM International:

- TCNA Handbook for Ceramic, Glass, and Stone Tile Installation
- EJ171 Movement Joint Guidelines for Ceramic, Glass, and Stone
- ANSI A108.01, *General Requirements: Structures, Substrates, and Preparation for Tile*
- ANSI A108.02, *General Requirements: Workmanship for Tile Installation*
- ASTM C1193, *Standard Guide for Use of Joint Sealants*

Generally, 12.7-mm (0.5-in) movement joints are required at intervals not exceeding 7.6 m (25 ft) on center in interior installations and not exceeding 3.7 m (12 ft) on center at



Figure 1: Due to a lack of any expansion joints in the system, the marble floor tiles exhibited chipping and spalling along their edges, where confined by relatively hard mortar joints.

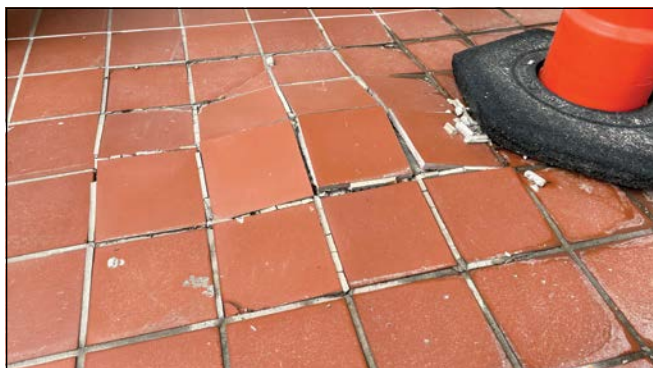


Figure 2: Without expansion joints in the system, the tile flooring buckled and heaved upward in hot weather.

exterior locations. More closely spaced or wider joints may be necessary for paving exposed to direct sunlight or subject to greater temperature extremes between winter nights and summer's full sun. Additional joints may be required at transitions in the underlying structure, at changes in materials, at architectural geometry such as reentrant corners or columns, at penetrations, and at the perimeter of each paved area. Because of the need to coordinate among different trades and to align movement joints with architectural geometry, the designer should specify the locations, details, and material specifications of the joints in the project documents. 



Kenneth Itle, AIA, is an architect and associate principal with Wiss, Janney, Elstner Associates, Inc. (WJE) in Northbrook, Ill., specializing in historic preservation. He can be reached at kitle@wje.com.



Katherine Augustine is an engineer and associate with Wiss, Janney, Elstner Associates, Inc. (WJE) in Northbrook, Ill., with experience in projects relating to the restoration of masonry structures and moisture leakage investigations. She can be reached at kjaugustine@wje.com

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