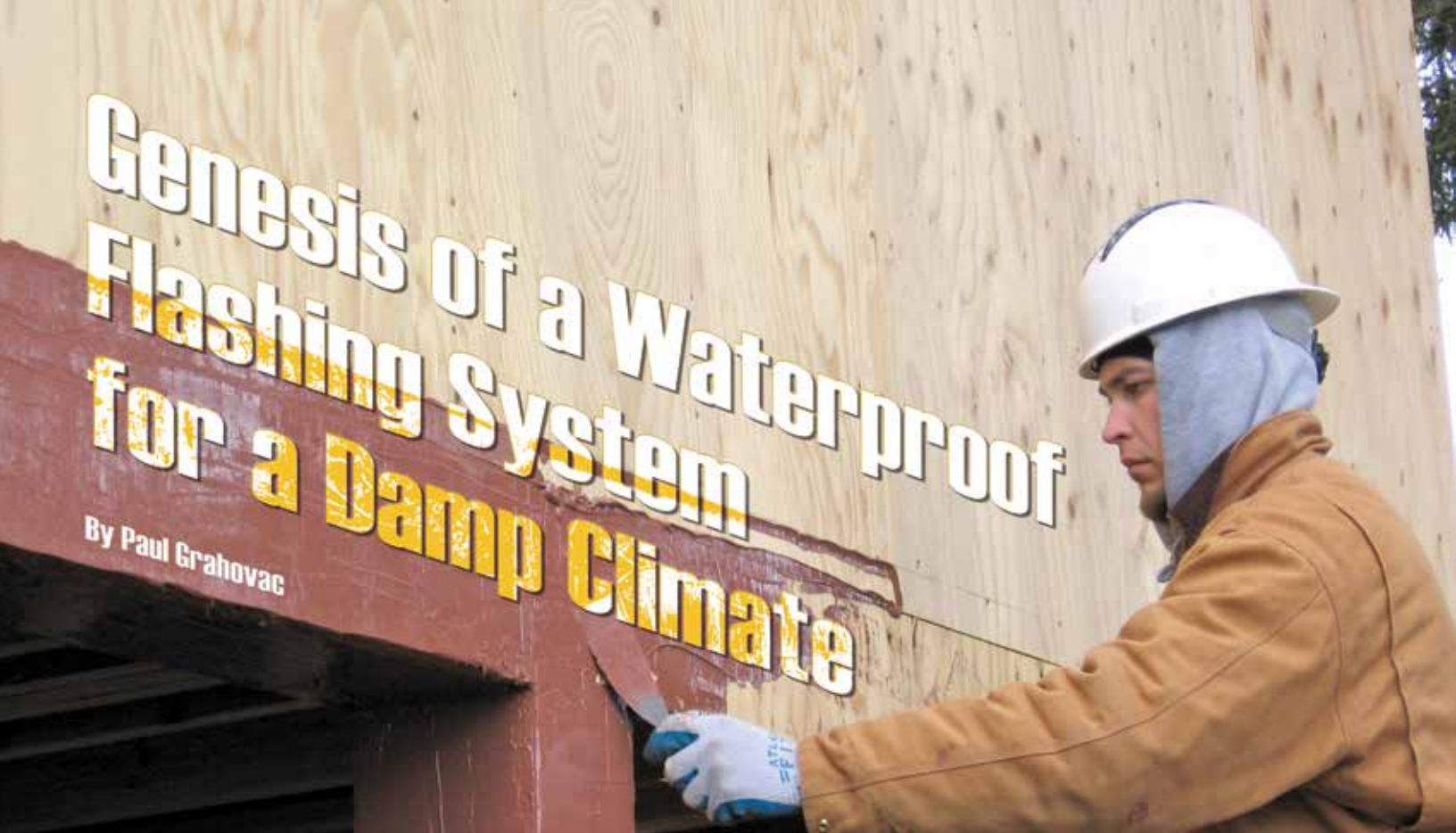


Genesis of a Waterproof Flashing System for a Damp Climate

By Paul Grahovac



The answers to common construction problems are out there. Tatley-Grund, Seattle, Washington, a contracting firm specializing in whole-building repair of water-damaged multistory structures, often sees failed peel-and-stick flashing membranes on rough openings.

During forensic investigations of buildings suffering water intrusion problems in the Pacific Northwest, principals Stacey Grund and Ron Tatley have documented repeated cases of adhesion failure that let water into the building envelope. See *Figure 1*.

“We’ve removed the cladding and seen the membranes peeled away and curled up,” Grund says. “We’ve seen where contractors have had to staple the membrane to the sheathing because it wouldn’t adhere to a wet surface.”

The majority of the firm’s work is on buildings less than five years old; far too young,



Figure 1 – This rotted plywood from a vapor-impermeable peel-and-stick that trapped moisture is typical of what repair contractor Tatley-Grund, Seattle, finds in water-damaged buildings. They found it counterproductive to repair problems like this with the same methods that they felt caused the damage to begin with. Photo courtesy of BEI, LLC.

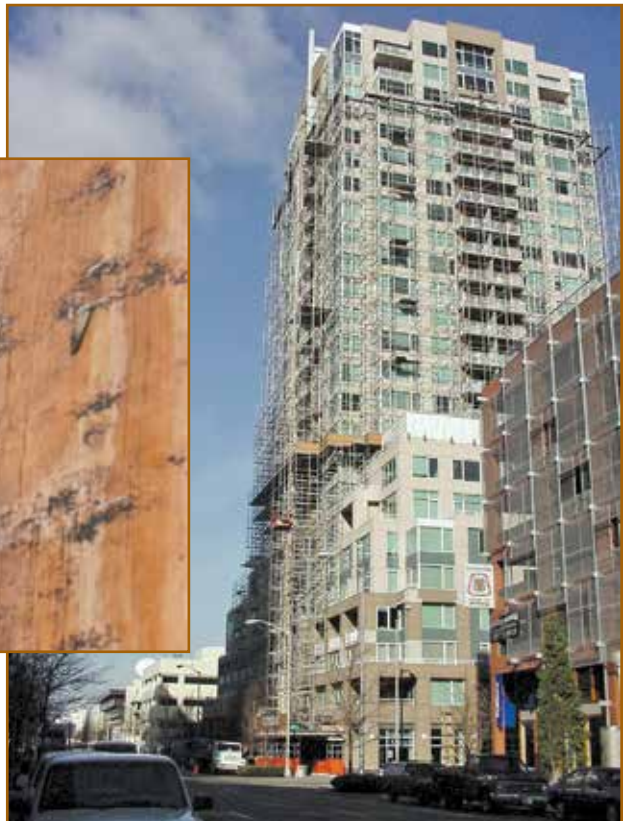


Figure 2 – Only three years old, this Seattle apartment complex had its cladding removed, windows replaced, repairs made to rough openings and sheathing, and cladding replaced at a cost of \$14 million after its traditional air-and-water barrier products failed. Tatley-Grund photo.

Grund says, to need this kind of repair (Figure 2). He has testified as an expert witness in over 85 lawsuits concerning these failures.

Part of the reason for the stream of building envelope failures rests with the unique climate of the Pacific Northwest, Grund says. Though the area gets less rain than is commonly believed, it has a high percentage of cool, wet days. That means not enough wet/dry cycles, which takes a toll on building envelopes.

Current methods also must shoulder some responsibility.

ASTM E2112 - 07, *Standard Practice for Installation of Exterior Windows, Doors, and Skylights*, requires 21 steps to properly flash a rough opening, creating, by some counts,¹ 74 interfaces between membrane and sheathing. In a multistory building with 300 windows, for example, that's 22,200 opportunities for air and water to leak through.

And in real-world circumstances—in a repetitious 21-step procedure repeated dozens of times a day—it's possible for even the most dedicated, competent installer to miss a step. Unfortunately, that one missed step can, and often does, compromise an entire wall assembly when it permits water intrusion.

It's no wonder that the U.S. Environmental Protection Agency's (EPA) Building Assessment Survey and Evaluation (BASE) study of 100 randomly selected U.S. office buildings found 43% of the buildings had current water leaks, and 85% had experienced previous water leaks.²

In their own work in the late 1990s, Tatley-Grund concluded it was counterproductive to repair water-damaged buildings using the same methods that appeared to fail in the first place.

Being contractors, they wanted a rough-opening flashing system that could meet the needs of their clients and the demands of the real world—especially the extra-damp Pacific Northwest. They wanted something simple to install that could tie into existing air, water, and vapor barrier systems, and that they could guarantee to their clients would not delaminate, rip, or otherwise fail for the designed life of the building. Unfortunately, nothing like that existed.

That didn't stop them. They began with a wish list. Tatley-Grund's ideal flashing system must:

- Bond to damp surfaces, since damp-

ness is a fact of life in the Pacific Northwest

- Be immediately waterproof in case of rain
- Be fluid-applied to avoid "buildup" that could affect how well the window fits into the rough opening
- Adhere permanently and without a primer
- Not shrink
- Be VOC-compliant, low-odor, and environmentally friendly
- Be opaque when target thickness

is achieved so the installer knows when the right amount is applied

- Withstand exposure to weather for up to six months in case of construction delays
- Be compatible with most paints
- Be vapor-permeable
- Have few and easy application steps
- Be easily repaired
- Self-seal around fasteners

Tatley led the search. For four years he tried and discarded urethanes, acrylics, and

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Property	STPE	Urethane	Silicone
Environmental friendliness	10	5	9
Nonbubbling	10	6	10
Low-temperature gunnability	10	8	10
Slump resistance	10	10	10
Quick cure	10	7	10
Storage stability	10	7	9
Body (tooling)	8	10	8
Weather resistance	8	6	10
Adhesion to various substrates	10	5	8
Mechanical properties	10	10	10
Heat resistance, mechanical stability	9	8	10
Nondirt pickup	10	10	5
Stain resistance	8	8	5
Paintability with water-based paint	10	10	3
Totals	133	110	117

Table 1 – Edward M. Petrie compared STPE, urethane, and silicone on a 1-10, worst-to-best scale. From *The Handbook of Adhesives and Sealants*, McGraw-Hill.

silicones. In 2004, after repeated unsuccessful tries with existing products, a silicone sealant manufacturer pointed to Tom Schneider, an expert in polymer chemistry. Schneider told the partners that with some work, a modified silyl (MS) polymer resin known as silyl-terminated polyether (STPE) might work for their purpose. Guided by the wish list, the Seattle contractors and the chemist worked together to harness the substance for flashing rough openings.

It turned out to be well-suited to the task. The result, an STPE-based fluid-applied flashing system meeting every checkpoint of the Tatley-Grund wish list, has been in continuous use, for both repair and new construction, since 2005.

Since then, the company has found the STPE resin versatile enough to be the base for a gun-and-spread joint and seam filler and a roller-applied primary air- and water-proof barrier.

Architectural Record magazine recognized the STPE-based flashing system in the publication's list of top waterproofing products of 2010.³

STPE CHEMISTRY

STPE-based products are the leading construction sealants in Europe and Asia—including Japan, where STPE was developed in 1978.

In their raw state, STPEs are clear resins. At the molecular level, STPE consists

of a polyether “backbone” with methoxysilyl chains on either end. With moisture and the proper catalyst, those chains condense together, creating weather-repellent, durable silyl bonds to hold the high-performance membrane together, Schneider explained.

This results in several of the properties Grund and Tatley sought for their wet locale, such as being instantly waterproof on application; being usable on damp substrates; and at the same time, curing even faster in case of contact with water, such as rain.

Those weren't the only reasons Schneider thought STPEs were good candidates for Tatley and Grund's flashing system.

Edward M. Petrie, author of McGraw-Hill's *Handbook of Adhesives and Sealants*, wrote a paper⁴ on silyl-modified polymer technology for The Adhesives and Sealant Council. In it, he compared MS polymers such as STPEs with urethane and silicone sealants. He used a table to show how MS polymers outperform the others across a range of factors (Table 1).

Petrie noted a major MS polymer drawback: strength loss over long periods of UV exposure. STPE-based rough-opening flashing and primary air and water barriers could be compromised in case of lengthy exposure during construction delays. That was one of several issues Schneider knew he would have to address.

FROM RESIN TO REALITY

The hardest part about going from the raw material to the finished product, Schneider said, was that there was no one to ask when he had questions. The overseas manufacturer of the raw material was tight-lipped, and few in the U.S. had heard of STPEs.

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Figure 3 – An applicator demonstrates the relative simplicity of waterproofing a rough opening with the STPE-based flashing system. Photo, courtesy BEI, LLC.

He started with what the resins already had that corresponded to the wish list: They were flexible; durable; and resistant to heat, cold, water, and chemicals. They were solvent-free. They could self-seal around and to fasteners. They had excellent adhesion on a wide range of substrates. They were vapor-permeable and had a suitable cure rate.

Unfortunately, the available STPE resins all varied in viscosity, flexibility, and strength, Schneider said. None was exactly right. He mixed and matched until he had a blend the contractors liked.

Alone in the laboratory, Schneider worked to create from the STPE resin a product with all the properties called for by Tatley and Grund's wish list. He experimented with UV inhibitors; treated pigments for impact-resistance; and increased vapor-permeability, flow characteristics, antimicrobials, and plasticizers.

Again and again he took his latest batch to Seattle for the crews to try out, and over and over he returned to the lab to try again. It was only a matter of time. That time turned out to be 2005.

FLASHING ROUGH OPENINGS

In its 2005 debut, here's how that first alternative to peel-and-stick membranes worked (Figure 3):

1. The waterproof flashing membrane,

- which they named Wet-Flash PM 7000, is gunned out of a cartridge and over the entire inside surface of the rough opening, 12 mils thick and 4 to 6 inches out onto the sheathing or CMU wall around the rough opening.
2. A pre-cured textile counterflashing is adhered to the bottom of the rough opening, folded over the sill, and pressed into the flashing material.
3. After a 15- to 30-minute cure time, the window goes in.

For flanged windows, the PM 7000 applies over the flanges except for drainage weeps left in the sill area.

That's simpler than the 21-step ASTM E2112 – 07 method.

Tatley-Grund's method also solved "buildup." In splicing and wrapping corners of rough openings with peel-and-stick, Grund said, installers sometimes find they've built up the surface an extra quarter to three-eighths of an inch. In those cases, windows have to be jammed in, which can damage the peel-and-stick and compromise the rough opening's watertight integrity. "That's one reason we wanted a fluid-applied solution," he said.

FIELD PERFORMANCE

The first field trials of the fluid-applied STPE flashing system took place on several

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Figure 4 – Ron Tatley makes some adjustments to the Design Verification Test Chamber he developed to test the air- and watertight integrity of wall assembly mock-ups. PROSOCO photo.

window-replacement projects in early 2005.

While the formulation lived up to most expectations, Schneider said it required adjustments for viscosity (it needed to be thinner), cure-time (it was drying too fast), and color. Applicator feedback indicated changing the color from gray to red would make it easier to inspect the flashing for correct thickness. A further refinement added fiber to the resin to reduce “drippiness.”

One of those early projects took place

in 2005 at Renaissance Condominiums in Seattle. In 2009, Tatley-Grund returned to the Renaissance Condominiums with independent inspectors from OAC, Seattle, a full-service architecture, construction support, and forensic engineering firm. The visit’s purpose was to inspect a representative sample of the building to gauge how well the STPE-based flashing had protected the rough opening and surrounding sheathing over the years.

With the owner’s permission, the investigators removed about 50 sq. ft. of Hardy Board siding and weather-resistive barrier on the building’s exterior to reveal the sheathing and rough opening. From inside the building, they cut an opening beneath the window so they could inspect the wall cavity. The inspection addressed the south and west corners of the building, since those are the elevations most exposed to Seattle’s wind and rain patterns, according to OAC’s report.

The report states the inspectors found Tatley-Grund’s flashing system in good repair and functioning as intended, and all inspected surfaces dry and in good condition. Tatley-Grund plans to reinspect in 2015.

Since Schneider’s first successful batch of STPE flashing material was applied on rough openings in 2005, he has helped Tatley-Grund pioneer other STPE-based products and procedures to make their repairs to water-damaged buildings more effective. They include a joint and seam filler and a roller-applied primary air barrier.

TESTING

Tatley-Grund’s STPE system passed ASTM E2357-05, *Standard Test Method for Determining Air Leakage of Air Barrier Assemblies*. In this test, the joint and seam filler, original flashing, and primary air barrier products—all derived from the STPE base resins—were tested at 75 pascals of pressure, corresponding to a 25-mph wind.

The system also passed the International Code Council Evaluation Service’s Acceptance Criteria 212 for water-resistive barriers. The water-resistive test requires the coating to perform at least as well as asphalt-impregnated building paper. Since climatic conditions in the Pacific Northwest routinely exceed the preceding test requirements, Tatley and Grund built their own test chamber in which they could subject mock-ups to more stringent weather simulations (Figure 4).

Testing assemblies rather than single products is important, they reasoned, since it doesn’t matter if an individual component can pass a test if the assembly fails.

Tatley built what was basically a giant metal box about 10 ft. high, 30 ft. around, and weighing around 12,000 pounds. See Figure 5.

Wall assembly mock-ups fit airtight into the open side of the box. The exterior side of the mock-up faces into the box, where there



Figure 5 – Ron Tatley (right) and assistant Matt Travis test a wall assembly mock-up in the Design Verification Test Chamber. Photo courtesy of PROSOCO.

are nozzles to simulate rain and fans to build air pressure. The interior side of the mock-up faces out, so inspectors can see where water is forced through.

Water almost always comes through, Grund says, because they usually test to failure. It's good to know exactly how much stress an assembly can take, he says. See Figure 6.

The Design Verification Test Chamber also features sensors and gauges to accurately measure that stress, which, Grund says, can be ratcheted up to Category 5 hurricane levels.

They've used the chamber to demonstrate the STPE system's ability to withstand hours of water spray driven at 2,880 pascals of pressure and racking movement corresponding to the 155-mph wind-driven rain of a Category 5 hurricane.

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AIR LEAKAGE TESTING

In chamber tests similar to ASTM E2357 air barrier assembly testing, but using a smaller mock-up, Tatley, Grund, and Schneider found their STPE system limited air leakage to 0.17 air changes per hour (ACH). That exceeds the 0.6-ACH passive house air leakage standard. It far exceeds the 5.0-ACH Energy Star standard for Climate Zones 3 and 4. See Figure 7.

The results are supported by recent project testing at the Karuna⁵ Passive House, under construction in Yamhill County, Oregon, where a partially installed STPE air barrier system achieved 0.42 ACH in blower-door testing.

COMPATIBILITY

Adhesion to a wide range of surfaces, including damp ones, was important, Grund said, since repairs require the flashing to tie into existing air, water, and vapor barrier systems. However, Grund noted that adhesion alone is not sufficient for long-term compatibility.

“For example, we’ve seen sealants with excellent adhesion on peel-and-sticks over the short term,” he said. “In the long term, some sealants block off-gassing from peel-and-sticks, resulting in

Figure 6 – An inspector points to where air pressure, simulating wind-driven rain, has forced a leak in a wall assembly mock-up during testing in the Design Verification Test Chamber. Photo courtesy of PROSOCO.



discoloration and damage. If you don't know from experience and/or prior testing whether two products will be compatible, it's best to test," he said. "We've found heat testing and accelerated weathering testing are good predictors of long-term compatibility," Grund added.

ENVIRONMENTAL

As sealants and adhesives, STPEs have long been known for environmental friendliness, another item on the Tatley-Grund wish list. They contain no solvents or isocyanates⁶ common to many sealants.

An STPE-based air and water barrier system derived from Schneider's formula was recently installed on the under-construction Bullitt Center in Seattle. The Bullitt Center is being constructed according to the requirements of the Living Building Challenge.⁷ When completed, it will stake a claim to being the greenest office building in the world.⁸ See Figure 8.

Builders chose the STPE system first for its demonstrated ability to hold air leakage to passive house and net-zero levels. They also chose it because it didn't have any ingredients from the Living Building Challenge's "red list" of environmentally harmful substances.

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Figure 7 – An installer seals a rough opening with an STPE-based flashing at an under-construction passive house in Yamhill County, OR. The builders chose the fluid-applied flashing because of demonstrated performance in stopping air leaks through the building envelope. Photo courtesy of Hammer and Hand.

Figure 8 – This architectural rendering shows the under-construction net-zero Bullitt Center, Seattle, WA. The Bullitt Center has an environmentally friendly STPE-based air- and waterproof flashing system to help it meet the stringent energy conservation standards required to be certified as a “Living Building.” Rendering courtesy of Miller-Hull Partnership.

CONCLUSIONS

In the end, this is not the story of a “miracle product” but simply that of existing chemistry being applied to and solving known problems.

“Although daunting to consider and potentially expensive on the front end, long-term solutions to difficult problems are achievable,” Grund says. “As was the case with Tatley-Grund over 10 years ago, the existing materials the market offered were insufficient. We took it upon ourselves to develop and make our own material/system. That resulted in a much better finished product for our customers and reduced risk and higher profitability for the company.”

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Paul Grahovac works for PROSOCO, Lawrence, Kansas, as the company’s Building Envelope Group technical director with 17 years of experience in the building products industry. The company manufactures products that clean and protect brick and stone architecture, including air and waterproof barriers. Grahovac’s professional activities include: LEED AP; International Code Council; Air Barrier Association of America’s Technical, Flashing, and Whole-Building Testing Committees; National Concrete Masonry Association’s Air Barrier Task Force; ASTM Committees on building performance, vapor permeability, and window installation; RCI; ASHRAE; and the following National Institute of Building Sciences Councils: Building Enclosure Technology; Environmental Council (BETEC Building Enclosure Integration Committee); and the Council on Finance, Insurance, and Real Estate.

