STEEP ROOFING –

Underlayment "Upgrades" that Sometimes Aren't

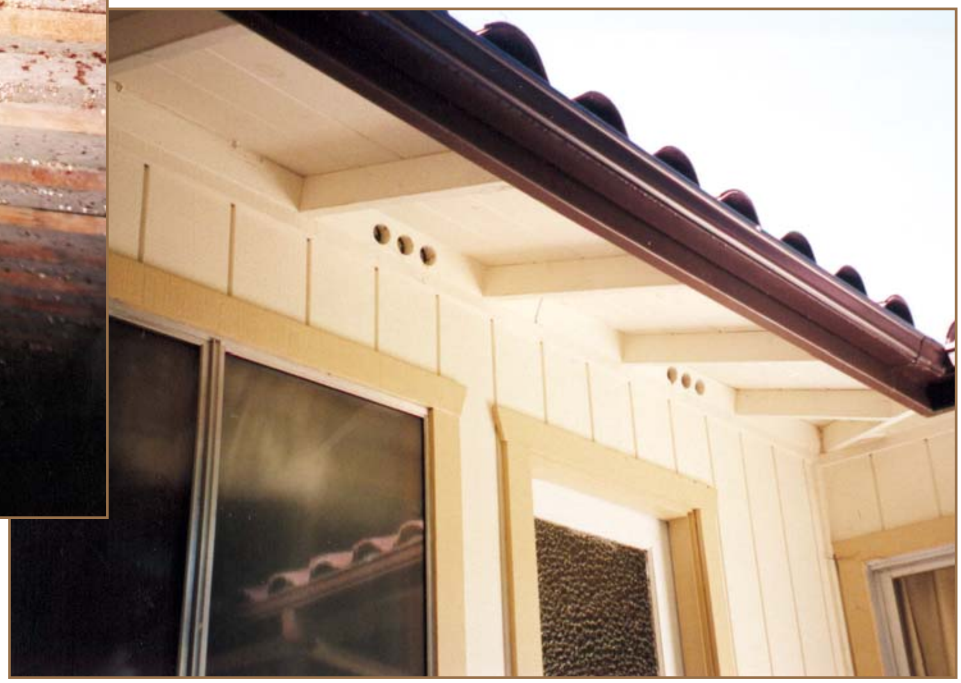
By Philip D. Dregger, RRC, FRCI, PE

Self-adhering, modified bitumen membranes are often installed as continuous waterproofing layers below steep-roof systems to enhance weather protection. Sometimes these "bullet-proof" roofs develop an unexpected problem – condensation. This article explains why and offers suggestions on how to enhance weather protection and reduce the risk of condensation.

This author acknowledges that self-adhering "ice and water" type underlayment membranes for steep roofing are useful in the marketplace. He has personally specified their installation as part of steep-roofing systems, including copper, slate, clay tile, concrete tile, and asphalt shingles. These products offer excellent waterproofing, and some possess a "self-sealing" characteristic around fastener penetrations. They are particularly useful to protect against ice dam conditions along eaves and to help achieve weather protection at penetrations, complex transitions, and terminations where rigid materials are inherently difficult to make weathertight on a long-term basis.

A problem can be created, however, when these products are installed without considering how they might foster the

Photos 1 (left) and 2 (above) – Steep roofs without conventional attic spaces (e.g., enclosed rafter spaces).



Photos 3 (left) and 4 (below) – Literally thousands of water droplets form on the underside of a plywood and spaced sheathing roof deck despite conventional attic eave vents on a project where a self-adhered membrane underlayment was installed as part of a roof replacement project.

potential for condensation.

Self-adhering, modified bitumen, sheet-type products are waterproof and quite flexible, but they are virtually impermeable to water vapor transmission. The manufacturer of one of the "ice and water" type products publishes a "maximum" water vapor transmission value of about 0.05 perms. In contrast, "15-lb asphalt felt" underlayment is listed in the ASHRAE Fundamentals manual as having a water vapor transmission rate (permeance) of about 1.0 perms (dry cup method) – or about 20 times more vapor permeability than the "ice and water" type product. Materials with perm ratings below about 1.0 or 0.5 perms are usually considered vapor retarders.

It is important to keep in mind that recommendations included in well-known manuals such as *Copper and Common Sense* by Revere Copper Products, Inc.; *Slate Roofs* by Vermont Structural Slate Co., Inc.; and *Architectural Sheet Metal Manual* by Sheet Metal and Air Conditioning Contractors National Association, Inc. discuss conventional felt underlayments but are generally silent in regard to "ice and water" type waterproof membranes, except along eaves with potential ice dam conditions.

Shake Roof Replacement

During an investigation of "leaks" reported the first winter after a wood-shake-roof in the San Francisco Bay Area was reroofed with concrete tile, this author observed literally thousands of water droplets covering the underside of the roof deck in the attic (see *Photo 3*). The owner reported no leaks (condensation-related or otherwise) from the previous wood shake roof that had been installed over spaced sheathing. The roofer reported that he had installed new plywood throughout and had even "upgraded" the underlayment from a conventional #30 felt to a self-adhered, modified bitumen membrane. Therefore, he was convinced the leaks were not his problem.

Although attic venting was about 50% of the code-required minimum, the old wood shake roof installed over spaced sheathing had been air- and water-vapor permeable just enough to avoid noticeable condensation. Installation of new plywood sheathing and a waterproof membrane changed this. The new plywood and waterproof membrane greatly increased the condensation-producing conditions by virtually eliminating any water vapor migration and "supplemental" attic air exchange that previously occurred directly through the wood shakes.

It is important to recognize that "ice and water"-type underlayment membranes are excellent vapor retarders; as such, if they are installed on the cold (exterior) side of the ceiling insulation rather than on the warm (interior) side, this can sometimes lead to problems.

Other projects where this author has observed very significant condensation conditions created or at least contributed to by the installation of self-adhering "ice and water"-type waterproofing membranes include several non-vented cathedral ceiling assemblies and copper barrel-shaped roofs (see *Photo 5*).

Condensation Basics

During the winter, the air inside a heated and occupied building typically has water vapor (and vapor pressure) in amounts well above that present in the air

Photos 5 (left) and 6 (below) – Saturated plywood sheathing below self-adhering membrane underlayment in a non-vented barrel roof with a standing seam copper covering.

outside. This difference in water vapor pressure works to equalize itself by some of the higher pressure interior water vapor diffusing or migrating outward through the walls and ceilings. (It's like air slowly escaping from a balloon.) As the water vapor migrates, it also cools. And, if it cools to its dewpoint, it will condense on a surface of one of the components within the roof or wall assembly.

Figure 7 shows severe deterioration caused by water vapor migrating through the ceiling of a laundry room and condensing on "cold," underside surfaces of a plywood roof deck above enclosed and insulated (but not vented) rafter spaces in Minnesota. Throughout the winter, water vapor in the air in the laundry room (68˚F, 50% RH) migrated upward and outward through the gypsum board ceilings and into rafter spaces filled with fiberglass batt insulation and covered by the plywood roof deck. Whenever the underside of the plywood was at a temperature less than the dewpoint of the water vapor in the air inside the rafter spaces (for this example, assumed to be about 49˚F), it condensed. Eventually, the plywood became wet enough (and warm enough) to support growth of wood decay fungi.

Mold (A Fungus)

In addition to decay, toxins produced by some molds have been linked to adverse health conditions. Since, among other things, mold requires moisture to grow, limiting condensation-producing conditions (including high-humidity) can help control the growth of mold in roof and wall constructions.

Condensation in Steep Roof Assemblies

Unfortunately, the mechanics of condensation in many situations are more complicated than illustrated in the above example. This is true for condensation in many steep-roof assemblies, with and without conventional attic spaces. (Note: Attic venting helps control condensation in at least two ways: first, by mixing moisture-laden interior air that enters with drier outside air before it contacts a surface below its dewpoint; and secondly, by facilitating drying of moisture that does condense on surfaces in the attic).

Condensation depends not only on how temperature changes along the path of water vapor migration, it also depends on

Photos 7 (left) and 8 (below) – Severe plywood deck deterioration with fungi growth caused by condensation over a laundry room in multi-family apartment building.

how the water vapor pressure changes along this same path. In fact, if a vapor retarding material is installed on the warm (interior) side and the other components of a non-vented roof assembly are sufficiently vapor permeable toward the cold (exterior) side, condensation will not occur, even though the "dewpoint" temperature is reached (i.e., the dewpoint temperature as calculated from the temperature and relative humidity of the interior air).

This is not so hard to believe when considering that the water vapor arriving at such a theoretical "dewpoint" location is "filtered" by each layer it passes through. Each layer – especially the vapor retarder layer – serves to hold back some of the water vapor and then, at the theoretical dewpoint location, the air and water vapor mixture isn't at a 100% saturation level. (Note: The ability of some materials to absorb water vapor is another reason why many steep-roofing systems over wood-frame construction in mild climates avoid noticeable condensation, even though simple dewpoint calculations would suggest otherwise.)

Wall Cladding

Condensation considerations for walls are similar to those for roofs. As with roofs, if impermeable membranes are installed on the cold side, excessive amounts of condensation can sometimes accumulate and fuel deterioration and fungi growth.

Re-Roofs

Consultants are often involved with reroofing over existing enclosed and insulated rafter spaces that are not vented (e.g, vaulted or cathedral-type ceiling assemblies) or over existing attic spaces that are minimally vented. Local building officials often do not require upgrading to comply with current code venting and vapor retarder requirements. If, in such cases, the new system includes an impermeable membrane above the deck, significant condensation conditions can be inadvertently created where they did not exist before.

Ventilation

When installation of a continuous waterproofing membrane beneath a steep-roof system is desired to enhance weather protection as part of a reroof project, this author strongly suggests checking and enhancing existing roof ventilation, even if not required by local codes. (Note: Also consider asking the owner to confirm that all flue, bath, and kitchen exhaust vents are operational and discharge humid air and combustion products (containing large amounts of water vapor) to the outside – not into attic areas.]

Non-Vented Assemblies

If the existing steep-roof assembly includes enclosed and insulated rafter spaces, and the reroof project does not or cannot include ventilation between the roof deck and the insulation, this author suggests proceeding with caution or considering not proceeding at all. Installation of insulation above the roof deck and installation of continuous vapor retarders on the warm (interior) side would be, in this author's opinion, a prudent practice in such cases in most climates.

Summary

Self-adhering, modified-bitumen membranes can enhance weather protection below steep-roof systems but can also inadvertently increase the risk of condensation by serving as vapor retarders on the "cold" side of roof/ceiling assemblies. Before specifying "ice and water" or other types of impermeable membranes that will completely cover steep roofs, this author suggests designers use caution and, as a minimum, comply with code-stipulated venting and vapor retarder requirements.

For steep roofs that do not have conventional attics (e.g., enclosed and insulated rafter spaces) or that have relatively high interior humidity conditions, this author suggests designers be conservative and, if needed, consider retaining suitably qualified individuals to consult regarding options (e.g., framed ventilation spaces, above-deck insulation, vapor retarders, mechanical ventilation systems, and interior humidity control systems) for controlling the accumulation of condensation moisture.

Future articles may address other important considerations such as interior air flow into insulated and non-vented air spaces (e.g., through unsealed lighting fixtures), complications associated with fire-control-related "draft stops" and "wrap backs," and the potential benefits promised by the new generation of watershedding, yet highly moisture-vapor-permeable underlayments.

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Roofing Demand to Expand Only 1%/Year Through 2010

U.S. roofing demand is projected to expand less than one percent per year through 2010 to 278 million square feet, with value expected to rise to $14 billion. The nonresidential construction market will provide the best opportunity for gains in the roofing industry, assisted by new office, commercial, institutional, and industrial segment expansion.

Among the various roofing materials, plastic and metal will see the fastest growth in the U.S. through 2010. Thermoplastic polyolefin (TPO) and spray-applied roofing will continue to make inroads. Metal roofing will continue to increase in popularity in commercial applications as well as residential markets, where metal panels, tiles, and shingles are being used as alternatives to roofing tile and asphalt shingles.

In 2005, asphalt shingles accounted for nearly 70% of the total installed square footage and will maintain the lead position through 2010. Demand for asphalt shingles will be constrained, however, by the weak outlook for new residential roofing.

Products designed to mimic asphalt shingles, roofing tiles, wood shakes and shingles, and slate will post gains, as will environmentally friendly products such as recycled roofing materials and composite shingles.

U.S. Roofing Demand
(million squares)

				% Annual Growth	
	2000	2005	2010	05/00	10/05
Total Roofing Demand	235.0	268.0	278.0	2.7	0.7
Asphalt Shingles	138.1	160.4	161.5	3.0	0.1
Bituminous Low-slope Roofing	34.3	34.5	36.0	0.1	0.9
Metal	18.5	19.9	23.0	1.5	2.9
Elastomeric	17.9	18.4	20.0	0.6	1.7
Other	26.2	34.8	37.5	5.8	1.5

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Most Tremendous Total Tear-off

Interface wants to know what projects consultants have seen or worked on that had the most individual layers of tear-off. We want to find the thickest roof out there. The roof that wins the Princess and the Pea contest: layer after layer after layer after layer – and still, it leaked! Send your experiences to Kristen Ammerman at kammerman@rci-online.org.