

# COOL ROOFS ON THE WEST COAST:

## *Has Roofing Science Been up to the Task?*

By Thomas J. Taylor, PhD

“Cool” single-ply membranes with highly reflective surfaces have come to represent over 50% of the commercial roofing market. Each year, well over 1.5 billion square feet of these white membranes are installed. However, as with many changes, there have been concerns about unintended consequences associated with this large shift. For example, in northern regions, condensation buildup has been a frequent concern. A review by this author showed that such instances were relatively rare, and that good roofing practices would largely avoid the issue.<sup>1</sup> However, that review was focused on systems using polyisocyanurate (polyiso) insulation installed above steel deck construction.

In the coastal regions of California, Oregon, and Washington (i.e., the West Coast), low-slope roofing is frequently installed over plywood or oriented strand board (OSB) decks above wooden rafters. Fiberglass insulation is installed between the rafters as shown schematically in *Figure 1*.

Fiberglass insulation facers are vapor retarders, but it is very difficult to install the product in such a way that air doesn't readily pass up through the system and into the space below the deck. Let's look closely at the features of this system that can contribute to condensation issues:

- **The roof deck is “cold”** – When insulation is installed above-deck, as with steel construction, the deck becomes part of the building interior

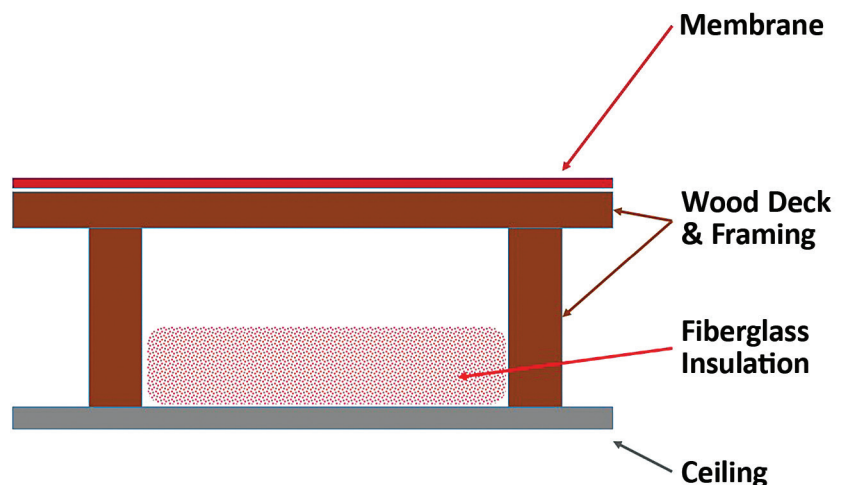
environment. Wood decks without insulation above them will readily equilibrate to the exterior temperature. During cooler nighttime and in winter periods, the deck temperature can then be below the dew point of the interior air; hence, the term “cold decks.”

- **Construction materials** – Wood-based products absorb moisture. Once the water content gets above 30% by weight, then rot is inevitable. Even if the air space is claimed to be vented, air flow is often insufficient to dry out the wood after condensation has been absorbed.
- **Insulation Type** – Fiberglass insulation is very porous, and if there are

any leaks around the edges of the facing, then air readily passes up through the system.

*Figure 2* shows the same wood deck roof, but indicates how moist air enters the system from within the building and condenses during cooler periods, such as night and/or winter.

Some commercial buildings might not even have a ceiling present, and air flow will be greater. However, an important point is that even if a vapor-impermeable air barrier is present, it is extremely difficult to install in such a way that moisture ingress is totally prevented. Also, since the roof membrane itself is vapor-impermeable, good building practice is to avoid double barriers.



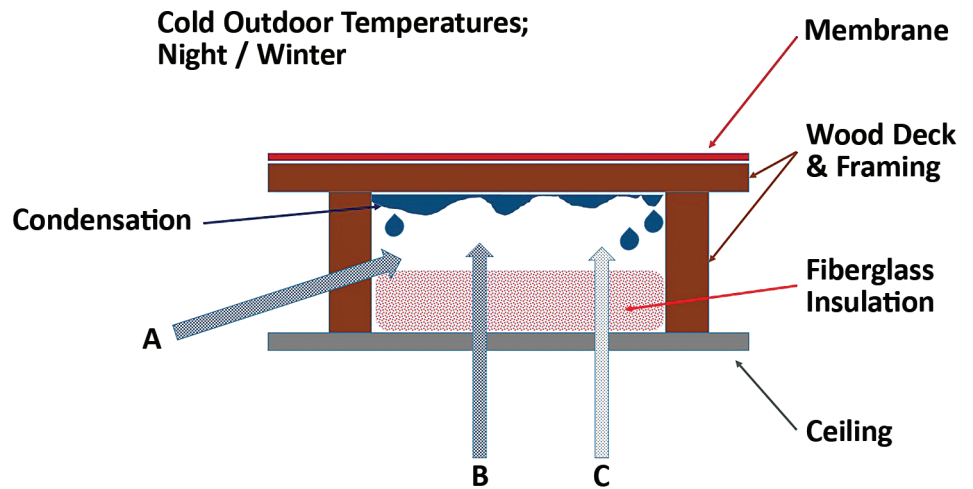
*Figure 1 – Schematic showing a wood deck roof system. For some building uses, the ceiling might be absent.*

The West Coast wood deck design was popular well before cool membranes became popular, so a key question is: What has changed? There has been significant conversation in the roofing industry speculating that cool membranes lead to more condensation. One real issue is that a key feature of the West Coast wood deck design was not widely understood or acknowledged: These were self-drying roofs, and cool membranes changed that.

A second issue could be the membrane attachment method. Built-up roofing and modified-bitumen (mod-bit) membranes typically are fully adhered to plywood decks. However, many heat-welded single-ply installations utilize mechanical attachment. That can lead to membrane billowing in high wind, which can “pump” air up from the building interior to the underside of the membrane,<sup>3</sup> shown in *Figure 3*. This only exacerbates the issue, bringing more moisture up into the system.

#### SELF-DRYING ROOFS

Before cool membranes, energy-absorptive membranes, such as ethylene propylene diene monomer (EPDM) and built-up roofing



*Figure 2 – Schematic of the wood deck system showing moisture ingress. A: air flow from walls and elsewhere in the structure; B: through penetrations; C: diffusion through vapor-permeable ceiling and paint.*

systems, were known to have condensation under the membrane.<sup>3,4</sup> The condensation would typically occur during cooler times of the day and/or season. However, during hotter times, these absorptive membranes would heat up and, in turn, dry out the underlying structure. This is shown in *Figure 4*.

The self-drying roof concept has been recognized for a long time.<sup>5,6</sup> However, there are some important points to be made about the wetting and subsequent drying-out process:

- The wetting and drying can occur at quite different times (e.g., different

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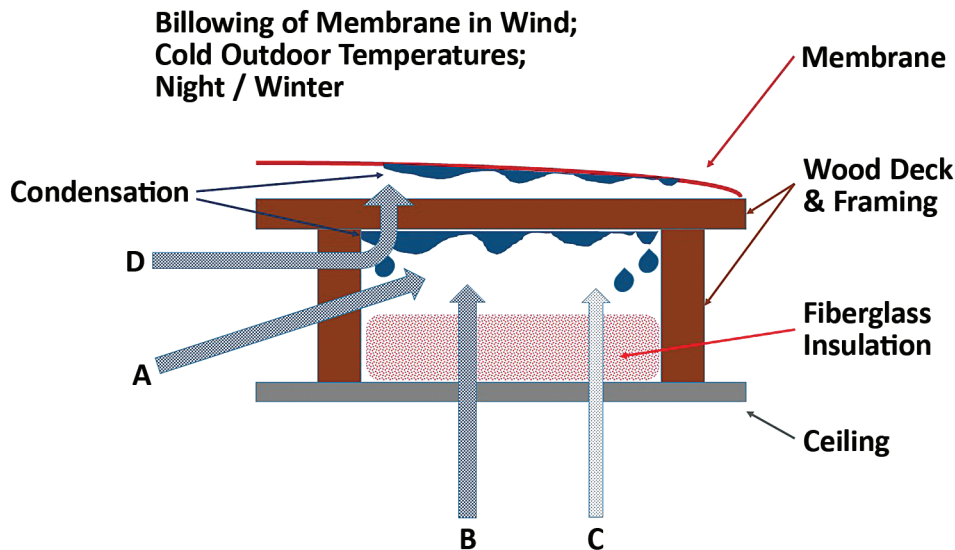


Figure 3 – Schematic of the mechanically attached membrane/wood deck system showing moisture ingress. A: air flow from walls and elsewhere in the structure; B: through penetrations; C: diffusion through vapor-permeable ceiling and paint; D: pumping of interior air into the system by membrane billowing in wind.

seasons).<sup>7</sup> This is true so long as the safe moisture storage capacity of the materials is not exceeded.

- Drying-out will take longer than the original wetting-out of the system. Downwards vapor drive is fundamentally more difficult. Warm air prefers to rise, and downward moisture migration will be more reliant on diffusion.
- The roof membrane temperatures required to dry out this type of system are not known with precision and are situation-dependent. This includes location, building use, and the exact construction details.

Dregger has pointed out that the balance between wetting and drying-out can be very delicate.<sup>8</sup> Some roof systems might be “on the edge” of having problems, and a reflective membrane simply forces the issue.

#### IMPROVING THE WOOD DECK ROOF DESIGN

The basic structure of a wood deck system, shown in Figure 1, actually has several drawbacks:

- As discussed, with reflective membranes, wood decks are no longer self-drying with respect to large amounts of condensation. Reflective membranes are required for many reasons, but the reduced ability to self-dry reinforces the fact that these

membranes reduce energy drive into a building structure. They are reducing air conditioning demand, and increased susceptibility to moisture is an unintended consequence.

- Instances of moisture condensation within these roofing systems demonstrate the difficulty of keeping interior moist air away from or below the underside of the deck. Sealing up the entire roof system is basically impossible, especially when one considers penetrations and how to seal

the ends of the rafter cavities. In fact, sealing up the system is bad practice, since it involves double vapor barriers.

- Since moist air can reach the underside of the deck, these structures are not as energy-efficient as intended.
- Mechanically attached membranes can billow in the wind and thereby “pump” more interior air up into the roof system.

There are recognized methods of improving on the wood deck roof system, listed below.

#### ADD INSULATION ABOVE THE ROOF DECK

This approach can be considered as an extension of the “continuous insulation” approach currently gaining ground in wall construction. Lstiburek referred to a concept of “the perfect wall,” in which the thermal control layer was on the outside of the structure.<sup>9</sup> Roof membranes are air- and vapor-impermeable and act as the weather barrier for the structure. “The perfect roof” would encompass weather, air, moisture, and thermal control—all above the structure. Insulation would not be part of the structure but would be entirely above-deck.

Unfortunately, there are many existing structures that were not designed with a “perfect roof” approach. However, as noted by Dregger, as well as Desjarlais et al.,<sup>10</sup> the addition of insulation above the deck

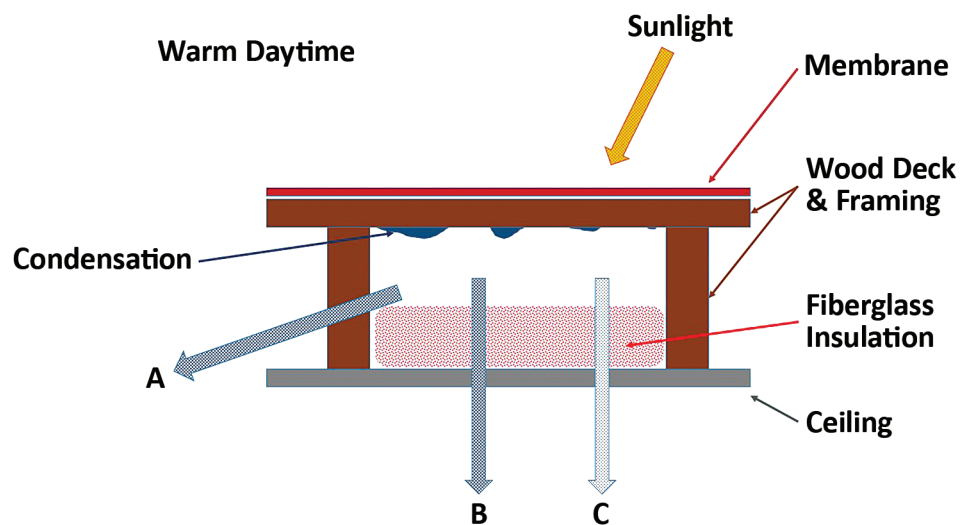


Figure 4 – Schematic of the wood deck system showing drying out. A: air flow down into building; B: through penetrations; C: diffusion through vapor-permeable ceiling and paint.

will keep it at temperatures closer to the building interior. Desjarlais et al. modeled roof systems in six West Coast locations and gave practical guidelines as to how much above-deck insulation should be considered. The study showed that in many cases, 1.5-in. polyiso would be sufficient. But roof designers must validate their specific designs for local conditions and the buildings in question. The degree of air infiltration into the roof system can significantly change how much insulation might be required.<sup>11</sup>

### USE FULLY ADHERED MEMBRANE ATTACHMENT

By fully adhering the membrane, one of the major differences between traditional built-up (BUR) and mod-bit roofs and many single-ply installations is eliminated. The importance of minimizing air flow up into the system can't be emphasized enough. The only exception is when cross ventilation is provided for and is sufficient for each enclosed space.

However, a difference might be that high reflectivity could negate the self-drying mechanism thought to exist with lower-reflectivity membranes, such as EPDM, as described by Powell and Robinson.<sup>3</sup>

### THE ROLE OF VAPOR RETARDERS

Whenever moisture and condensation issues are present, there is a great temptation to install some kind of air/vapor barrier. However, great care needs to be taken before embarking on such a route and specifying exactly what type of barrier is required.

- It is extremely difficult to seal all air leakage paths into a framed roof system that incorporates thermal insulation. Therefore, it is inevitable that interior air will infiltrate. If air barriers are to be used, installation should be very carefully thought through. Also, only vapor-permeable air barriers should be used.
- It can be tempting to think that a vapor barrier will automatically prevent moisture from entering the system. However, the result would be to enclose the roof system with two vapor barriers: the membrane on top, and the vapor barrier on the underside. Any moisture that does get in will not be able to leave.
- In those instances where the building designer deems that an air barrier is

essential, that barrier should have some vapor permeability. Ideally, the underside of the roof system should be enclosed with a vapor retarder if the building designer wishes to reduce moisture ingress.

### CONCLUSIONS

Highly reflective roof membranes installed over West Coast wood deck systems can lead to moisture buildup in the wood system. Once this buildup exceeds the safe storage level of the components, then

structural issues can occur. Inadvertently, the so-called cool membranes have reduced the ability of these wood systems to be self-drying.

- The West Coast wood-framed and decked systems usually incorporate insulation within the system, as opposed to above the deck, as in steel-framed construction. Designers of roof systems, whether for new construction or reroofing, need to install sufficient above-deck insulation whenever practical.

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- Reflective membranes should be fully adhered to prevent wind-driven billowing and pumping of air up into the system.
- If the roof designer chooses to install an air barrier, it is recommended that it be a vapor retarder.<sup>2</sup> 

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## Wanda Edwards Named to Advisory Committee of National Windstorm Impact Reduction Program

RCI Senior Director of Technical Services Wanda Edwards has been appointed to represent RCI as a member of the Advisory Committee of the National Windstorm Impact Reduction Program.

The program was established by Congress "to achieve major measurable reductions in the losses of life and property from windstorms through a coordinated federal effort, in cooperation with other levels of government, academia, and the private sector, aimed at improving the understanding of windstorms and their impacts and developing and encouraging the implementation of cost-effective mitigation measures to reduce those impacts." As designated by Congress, the National Institute for Standards and Technology (NIST) is the lead agency for the program, and will work with the Federal Emergency Management Agency (FEMA), the National Science Foundation (NSF), and the National Oceanic and Atmospheric Administration (NOAA) to coordinate research and implementation activities.

The 15-member Advisory Committee is charged with offering assessments and recommendations on trends and developments in the natural, engineering, and social sciences and practices of windstorm impact mitigation; the priorities of the National Windstorm Impact Reduction Program's Strategic Plan; the coordination of the program; the effectiveness of the program in meeting its purposes; and any revisions to the program that may be necessary.

The Advisory Committee will meet several times between April and September to carry out the charge of the committee.