Energy Efficient Roofing Metrics

Part 1: Cool Roofs: Reflectivity Matters

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When facility executives start planning energy efficiency projects, usually the first things on the agenda are HVAC systems and lighting. Roofing doesn't usually make the top of the priority list.

In reality, except for on very tall buildings where the majority of the exterior envelope is walls and windows, the roof most assuredly affects the money spent to heat and cool a building. The key to energy efficiency in a roof is heat transfer.

Roofs bake in the sun all day, absorbing heat from the infrared and near infrared components of solar radiation. Some of this heat is given off but some is transferred into the building. Conversely, the roof cools in the night and transfers heat from the interior of the building to the outside air. This heat loss or heat gain (depending on climate and time of year) directly affects energy use. Logically speaking, the less heat transfer, the less the HVAC system needs to run. Thus the most energy efficient roof is the one that contributes the least to heat transfer.

To understand energy efficiency in roofing, one needs to understand some terminology — reflectivity, emissivity and thermal conductance. Reflectivity is the ability of a surface to cause radiation to bounce off rather than absorb. Emissivity is its ability to release what has already been absorbed. Thermal conductance is the materials' ability to transfer heat through itself to another material. Each of these three concepts will influence the heat transfer of a roof and impact the energy costs of a building.

Reflectivity

Dark materials absorb more heat than light materials and shiny surfaces reflect more than dull surfaces. This is a function of the reflectivity of the surface. A black or dark colored roof system will absorb more heat than a light colored one. The ability of a light colored surface to reflect the infrared and near infrared spectrum keeps the heat from being absorbed in the first place, keeping the roof membrane and the materials below it cool — hence the term "cool roofing."

Any type of roof system can be cool. Although the TPO and PVC single plies are best known for their reflectivity, most other roofing system manufacturers have developed reflective versions of their traditional roofing systems. EPDM manufacturers have developed pure white EPDM systems and are laminating white surfaces to the traditional dark grey materials. Built-up system manufacturers have developed pure white systems including white adhesives and aggregates to provide reflective surfaces. Modified bitumen roofing manufacturers have developed new cap sheets that are blindingly white next to the traditional light gray granule surfaces. Almost any roof, new or existing, can be made into a reflective roof by applying coatings to obtain the solar reflectance values needed to comply with California Title 24, Energy Star ratings or LEED certification.

If the roof is low slope, there are other considerations to assure the reflective roof continues to provide the same benefits as when it was installed. Dirt will accumulate on the roof surface and reduce the reflectivity. One study by the Lawrence Berkeley National Laboratory Heat Island Group showed significant reductions for different coatings from dirt accumulation on the roof. The reflectance dropped the most during the first six months after installation and did not significantly decrease for several years after. Washing the roof with a mild detergent and water caused the reflectance to rise again. Washing the roof with a high power pressure washer is not a good idea because it can damage the membrane. Washing should be done with low pressure and a mild detergent. Bleach is not recommended, especially for an asphalt-based roof system.

One side note: A roof does not have to be white to be reflective. Research into heat-reflective clothing for military use has resulted in colored pigments that reflect infrared and near infrared radiation. This has been adapted by the roofing industry, especially metal roofing, to provide colored alternatives for reflective roofs. Some TPO single ply membranes have also included this technology in their formulations, allowing bright colored materials as well as light ones.

Part 2: Cool Roofs: Emissivity Standards

Reflectivity is only a part of the story, however. Just because a roof is reflective does not mean that it is cool. It also needs to be able to release any heat it absorbs back out into the atmosphere. For buildings, if the roof has low emissivity, the materials directly below it get hot — the insulation, deck and ceiling — eventually reaching the interior. Better to release the heat back into the atmosphere than into the building where it will need to be mechanically removed or cooled. LEED has taken this relationship into consideration, requiring a roof to be not only highly reflective, but also highly emissive. The California Energy Commission adopted changes to the Building Energy Efficiency Standards contained in the California Code of Regulations (CCR), Title 24, to include cool roof prescriptive requirements for roofs, use of three-year aged solar reflectance data, and requirements by climate zone.

Conversely, in very cold climates, where heating loads tremendously exceed cooling loads, facility executives may want low reflective and low emissive roofs to retain what little solar radiation can be captured. Any heat absorbed into the building by the dark surface will lower costs for heating the interior.

Part 3: Cool Roofs: Emissivity Standards

The third factor that affects the energy efficiency of the roofing system is the thermal conductance of the roofing materials. Most roofing membranes have high thermal conductance — whatever gets into the membrane gets out just as fast. To counteract this, thermal insulation has been a part of roofing systems for many years. The thermal resistance of the roof assembly — from the air that flows over the top of the roof, to the roof membrane and insulation, to the deck and the air that flows below the roof as well as any ceiling systems — is calculated into a total value for the thermal resistance of the building: the ability of the assembly to allow heat to transfer from the interior to the exterior or from the exterior to the interior depending on the season and climate.

Adding more insulation to resist heat transfer is one way to compensate for a non-reflective roof system in a warm climate. Similarly, the more insulation used in facilities in cold climates, the better the assembly's ability to minimize heat loss from the warm interior to the cold exterior. This resistance (R-value) has been mandated by building code and in ASHRAE 90.1. As the requirements for energy efficiency get more stringent, so does the R-value of the roofing system that is mandated. The 2010 version of ASHRAE 90.1 is expected to mandate a 30 percent reduction in the energy use of a building from the 2004 version — meaning the R-values of the roof will very likely need to be increased even more.

Energy efficiency of a building can be impacted for good or for bad simply by the choice of roofing materials. Increasing the R-value of the thermal insulation of the roofing system can provide an easy way to increase the energy efficiency of the building.