



Options to Consider for Title 24 Roofing

Photo courtesy Hutchings Design Group

by Jim Jannasch

In 1978, the California Energy Commission (CEC) established the *Energy Efficiency Standards for Residential and Nonresidential Buildings* in response to a legislative mandate to reduce the state's energy consumption. These standards, which became known as Title 24, are updated periodically to allow consideration and incorporation of new energy efficiency technologies and methods.

Last October, revisions to Title 24 of the *California Code of Regulations* were introduced. While the code has been in effect for nearly 30 years, the latest update on the so-called 'cool roof' requirement is new. As such, it is frequently misunderstood, particularly at the contractor and specifier levels. This article discusses the misconception over Title 24, presenting other

options to meeting the requirements beyond simply installing a reflective roof. It also examines the results of several studies, such as those on the reflectivity of ballast stones, along with ongoing discussions that could potentially impact the scheduled 2008 revisions to this stringent energy code.

Taking a closer look

Most building teams automatically assume a reflective roof is the only way to meet Title 24 revisions. This stems from the misconception a cool roof is the sole method of compliance available, given it is listed as prescriptive in California's energy code. However, it is clear from reading section 3.4.2 of the *Nonresidential Compliance Manual for California's*



Complying with Title 24 via the whole building performance approach could mean making tradeoffs, like installing additional insulation, and more energy-efficient air-conditioning units and windows, along with low-wattage lighting.

2005 *Energy Efficiency Standards* that a cool roof is not mandatory. In other words, this system is required only if the owner or designer chooses the prescriptive method of compliance. Since the intent of Title 24 is to ensure each building meets its energy budget rather than dictate the color of the roofing membrane, other options can be used, such as adding insulation, upgrading the efficiency of the mechanical equipment, or changing the design of the window or lighting system.

Despite the hype about white roofs, the reality is specifying the right roof system for the right climate is not simply a white versus black issue. Using the Department of Energy's (DoE's) cool roof calculator, it is possible to calculate the estimated cooling and heating savings for flat roofs with non-black surfaces.¹ This tool also informs the user on how much additional insulation is required to yield the same annual energy savings made possible with a black roof.

For example, the calculator found a dark roof could be used with only a slight increase in R-value when Los Angeles and San Francisco, California, were selected as locations. In the Los Angeles scenario, using an R-10 with a cool roof required upgrading to an R-11 to get the same energy savings made possible when using a black roof. Similarly, in the calculation for San Francisco, a small increase to an R-10.4 would be required.

If a building owner wants to install a cool roof that is not considered reflective by the Cool Roof Rating Council (CRRC), they need to use the envelope approach. This is in consideration of the fact Section 3.4 specifically requires a CRRC-listed roof.

The energy code also does not consider mitigating factors, such as the aesthetic tastes of a particular geographic location.) That is, many Californians prefer earth tone colors be used in building exteriors.)

Refining cool roof requirements

The current version of Title 24 defines a cool roof as a roofing system of any color with a minimum solar reflectance of 70 percent and thermal emittance of at least 75 percent. Studies on white roofs show these systems lose up to half their reflectivity within three years.² Title 24 bases its model calculations on 'as-built' reflectivity and does not account for the loss of reflectivity that can be seen in as little as six months after installation. Therefore, this author recommends altering the 70 percent reflectivity typically written into specifications during the design phase to a number closer to 50 percent to account for the loss in reflectivity as the roof ages.

Andre Desjarlais, with the Oak Ridge National Laboratory (ORNL), is among several contributors to the ongoing debate over how to implement the existing code. In his study, *Peak Demand Energy Analysis: Roof Reflectivity and Insulation R-value*, he suggests refining the cool roof energy code requirements. This study was published in March 2006 and funded by the Asphalt Roofing Manufacturers Association (ARMA), Solar Smart Roof Alliance (SSRA), and the DoE. It shows meeting Title 24 is also possible by following the alternative envelope approach, instead of the prescriptive path.

The Title 24 energy code has evolved since its inception in 1978, partly in response to the failure of voluntary energy-

saving efforts made since the 1970s that were often overlooked by more pressing efforts to house and provide workplaces for California's exploding population. Other recent factors undercutting energy savings have been exceptionally hot temperatures and brownouts, most of which occurred during the hottest days of the year when air-conditioned buildings consumed too much power and utility companies struggled to meet peak demand.

As previously mentioned, a design/construction team not pursuing the prescriptive approach could still consider the envelope method. This option looks at overall heat loss and heat gain, along with insulation, while also measuring the quality of the insulation. A reduction in solar heat gain (SHG) can be achieved by adding insulation without the need for a reflective roof. The DoE's calculator lays out insulation requirements for black or white roofs. In some cases, especially northern California, a black roof may provide more desirable results because of the heat gain achievable with such a membrane.

In an effort to provide owners with an equitable way of formulating an energy budget for their buildings, CEC split the state into 16 climate zones and determined the amount of energy per square foot a building would be allowed to consume. Within the 16 climate zones, the code assigned a



A ballasted EPDM roof tops Parkland High School in Allentown, Pennsylvania. This type of roofing system can offer warranties as long as 30 years and earn up to 12 LEED points. Its cost may also be less than other systems, allowing the difference to go towards upgrades in energy-efficient lighting or windows.

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The current version of Title 24 defines a cool roof as a roofing system of any color with a minimum solar reflectance of 70 percent and thermal emittance of at least 75 percent. Model calculations are based on 'as built' reflectivity.

time-dependent valuation multiplier used to measure energy savings during periods of peak demand. This is similar to the premium charged by electricity companies for energy consumed during the hottest hours of the day, in the hottest months of the year.

The multiplier, which provides extra credits for energy savings during peak times, favors a cool roof and provides the baseline in the energy code for any other potential energy-saving strategies. It also favors a cool roof because it is the easiest, simplest, and often least expensive way for the roofing materials to assist in compliance with the energy code. However, there are other options. For example, a black roof with a 25 R-value roofing insulation might provide the same level of compliance as a white roof with an R-value of 20.

Three approaches to specifying

There are three ways to comply with Title 24—prescriptive, building envelope, and whole building performance. The prescriptive approach entails installing a reflective roof membrane, eliminating the need for energy calculations at the design stage before gaining approvals for the project. However, if a designer or contractor decides to comply with Title 24 by using a system other than a prescriptive cool roof, the result could mean exceeding their energy budget on the one hand and making up for the difference by adding insulation on the other. As mentioned earlier, this may be minimal in nature and add little expense to the project. However, due to the specialized nature of the calculations, they can only be made by a third-party consultant using CEC-approved software. This is both costly and prohibitive for many building teams, often resulting in a decision to take the prescriptive approach.

With the envelope approach, the overall energy efficiency of the components are assessed together. This includes windows and skylights, as well as the reflectance of the roof. Taking the

whole building performance approach could mean making tradeoffs, such as installing additional insulation, more energy-efficient air-conditioning units, windows, low-wattage lighting, or some other strategy to stay within a Title 24-mandated energy budget. This presents less of a burden for new construction because the costs can be evaluated at the design phase when the potential for value engineering exists. While the initial cost may be higher with the performance approach, it is still not as costly as a re-roofing project.

Cost considerations

The cost of re-roofing to comply with Title 24 can be prohibitive in cases where a contractor has 'non-listed' CRRC-roof specification to follow. With such a system, the energy budget can require adding more insulation, as well as new windows or lighting etc. This is often beyond the scope of the roofer's contract and adds significant costs to the price tag a building owner may face for a routine roofing restoration.

No two roofs cost the same. A CRRC-roofing specification makes it easier to comply with Title 24, but the cost for a typical ballasted ethylene-propylene-diene-monomer (EPDM) roofing system, for example, may be less, allowing for monies to be used for upgrading to more energy-efficient lighting or windows. In many cases, a dark-colored roof can be just as energy-efficient as a cool roof by adding additional R-value. Also, labor rates vary greatly from contractor to contractor and will also influence the final cost of a project. A contractor who is fluent in the installation of a particular EPDM system will more than likely quote the job less than that of a white thermoplastic roof simply because of his familiarity and proficiency with the system.

This fact is further expanded upon in a recent submission to the CEC by the Asphalt Roofing Manufacturers Association, which submitted a 'snapshot' survey—*Low Slope Roof Costs:*

Cool Roof Premiums—showing the premiums often paid by building owners for cool roofs as part of a low-sloped membrane roof covering on nonresidential building in California. This document, and all others, was submitted for consideration as the CEC moves toward the commission's 2008 Title 24 update to the *Building Energy Efficiency Standards*.

Further details about the compliance approaches to Title 24 are contained in two of its sections. The first deals with the prescriptive method of compliance and the second is devoted to the performance approach. Section 142 refers to performance approach provisions, which are of interest to building teams that do not intend to install a cool roof on their new construction and restoration projects. Section 143 lays out the prescriptive approach—subsection (a) outlines the basic 'check-off' method of the prescriptive process and (b) addresses the overall envelope method for component tradeoffs.

For the building owner or designer taking the performance approach, there are several new tools available to help calculate and compare energy savings. The DoE has developed a Web-based cool roof calculator, which allows the building designer to compare the relative economic benefits of thermal insulation to roof surface reflectivity. In addition to the DoE calculator, the National Roofing Contractors Association (NRCA) has developed the EnergyWise roof calculator. This CD-based calculation tool offers an interactive, graphical method of constructing virtual roof assemblies to evaluate thermal efficiency and approximate annual energy costs. This user-friendly program prompts the designer to enter specific roof assembly information, such as roof area, climatic region, heat type and cost, roof openings, and roofing materials. It then generates a report summarizing estimated heating and cooling costs, which in turn, can be used to determine optimal tradeoffs in building design.

It is worth noting there also seems to be a contradiction between section 149 of Title 24 and the SSRA's assumption the existing insulation can be used in the overall envelope method for the re-roofing budget calculation. CEC is now reviewing this, along with many other issues included in the group's ongoing series of workshops. The commission continues to accept papers, testimony, and input from stakeholders to finalize a draft of the 2008 revisions to Title 24. (CEC posts new findings and papers in an ongoing manner on its Web site.)

Roofing-related revisions, such as aged values and increased insulation levels across California, are likely to be topics on the commission's agenda before the revisions are finalized.

Site specifics

California's energy-saving requirements and the debate about Title 24 regulations could be significant in other areas of the country, where energy policies already exist or are being considered, such as New York City, Nevada, Texas, Florida, and Chicago, Illinois. The discussion could also spark changes in other codes such as American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 90.1 *2004 User's Manual*, 90.2 *Energy-efficient Design of Low-rise Residential Buildings* and the *International Energy Conservation Code (IECC)*. While the cool roof concept continues to grow, additional testing of ballasted systems and lifecycle analysis (LCA) of white versus black roofing membranes are expected to balance the playing field. The long-term sustainability of a ballasted roof compared to thermoplastic membranes has yet to be explored by energy regulators.

For example, light-colored rock ballast or ballast pavers are not Energy Star®-rated. As such, they currently cannot

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Photo courtesy of Hutchings Design Group

There are several tools available to calculate energy savings. The U.S. Department of Energy (DoE) has developed a Web-based cool roof calculator, allowing building designers to compare the relative economic benefits of thermal insulation to roof surface reflectivity.

be classified for several reasons in the same way white roof membranes receive their third-party verification. Reflectivity is measured by an instrument, which monitors the differential between the sun's incoming rays and the heat-generating wave lengths bounced back in a linear path. A rock reflects those rays in many directions, making linear measurements inaccurate. Therefore, the focus should remain on the mass of the ballast as a heat shield. In the final analysis, a cool-ballasted roof system might be the best choice for a particular geographic location, use, sustainability, and maintenance requirements, even though it might not earn third-party verification.

Additionally, any cool roof with an Energy Star rating should be only one indicator of a membrane's long-term performance. This program, which rates roofs as well as refrigerators and air conditioners, measures its standard in a factory-controlled environment. Given this, applying the standard to roofs may be unrealistic because a factory-controlled environment does not include soot and dust, which accumulate on white roof membranes in the real world. Additionally, the shape of rocks used in ballasted roofs and the fact the systems are assembled on-site mean measuring reflectivity may be impossible.

Even though the reflectivity of ballast rock may never be measurable, there are still benefits to ballasted EPDM roofing systems. Depending on the weight of the stones or density of pavers used on a ballasted EPDM roof, a time delay in cooling a building until off-peak hours can be realized. By delaying the need for air-conditioning beneath a ballasted roof, this system can be an effective alternative to white membranes.³

Studies currently underway at ORNL are finding a ballasted system can be as energy-efficient as a highly reflective roof

after two years of service. (This study has been underway for the past two years and will be completed in the spring of 2007.) Currently, efforts are underway at the EPDM Roof Association (ERA), in conjunction with both CEC and the U.S. Environmental Protection Agency (EPA), to consider ballasted EPDM systems as 'cool roofs.'

In a slightly different focus, the U.S. Green Building Council's (USGBC's) Leadership in Energy and Environmental Design® (LEED®) rating program considers the sustainability, lifecycle, and broad environmental impact of roof systems. EPDM membranes are not only recyclable, but in the case of a ballasted system, they can also be reused many times, lessening the strain on natural resources. Additionally, EPDM roofing systems can offer warranties as long as 30 years and earn up to 12 LEED points.

A 2002 ORNL study, *The Field Performance of High-Reflectance Single-Ply Membranes Exposed to Three Years of Weathering in Various U.S. Climates*, looked at the long-term effect of sheet membrane reflectivity. It indicated all membranes lost reflectivity, some as much as 50 percent. This was one of several indicators many white membrane surfaces are not regularly cleaned to peak performance levels. To keep a white roof at peak performance, it should have at least a reflectivity of 0.655 or higher.

Dirt accumulation can affect the reflectivity of a white roof and dull its potential for energy savings. Still, absent from any discussion on maintenance is the standardized procedure for cleaning the membrane and what affect various cleaning methods have on its lifecycle. In most cases where a thermoplastic roof is power-washed to maintain its reflectivity, the membrane itself can erode from the cleaning

process, shortening the roof's lifecycle. Additionally, cleaning this kind of roof can be costly if it must be done twice a year. Roofing industry professionals report upward of between two to 10 cents per square foot for power-washing a fairly sizeable roof. On smaller roofs, the price can increase to 30 cents per square foot, depending on the complexity of the roof and its accessibility.

Since the release of the ORNL report, other studies are showing considerably less reduction in reflectivity. For example, a Western States Roofing Contractors Association (WSRCA) study entitled, *Performance Evaluation of Unexposed and Field Exposed Thermoplastic Polyolefin*, found an average loss of reflectivity of 22 percent after four years. Also, the four-year aged value almost equaled the Energy Star new requirement (*i.e.* 0.641 versus 0.65). This study showed these particular roofs were still at 0.65, although they started at 0.80. However, those results were for very unique climates (*i.e.* San Antonio, Texas; Las Vegas, Nevada; Seattle, Washington; and Anchorage, Alaska). These types of results cannot be assumed for all buildings in all geographical locations and this author recommends using 0.50 as the reflectivity number when making calculations.

Conclusion

Whether the overall objective for building a cool roof is reflectivity, emissivity, energy efficiency, heat-island reduction, environmental stewardship, or building green spaces, a cost-benefit analysis of sustainability must be part of the equation. However, the long-term performance for sustainability is an altogether different issue.

None of the cool roof definitions and measures address long-term performance, which remains the best measure of lifecycle sustainability. A true

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There are three ways to comply with Title 24—prescriptive, building envelope, and whole building performance.

cost-benefit analysis might illustrate how highly reflective roof systems increase water consumption and maintenance expense over the life of the roof. At this point, there is simply not enough evidence.

Technology might be changing the landscape of rooftops, but the basics still apply. The best course of action is to ask goal-clarifying questions and work with professional contractors who care about the lifecycle of their work, buy quality materials, and develop a budget that aligns with objectives. Also, it is critical the specifier know what options are available under Title 24, specifically the possibility to choose either the performance or prescriptive approaches. The calculations must be examined and the section on how to obtain Title 24 permits are also important to check, as Section 2-6 spells out the responsibilities of a specifier. ♡

Notes

¹ Visit www.ornl.gov/sci/roofs+walls/facts/coolcalcenergy.htm.

² See *Field Performance of High-Reflectance Single-Ply Membranes Exposed to Three Years of Weathering in Various U.S. Climates*, August 2002, Oak Ridge National Laboratory.

³ See a white paper presented by Gillenwater, Tome Petrie, Bill Miller and Desjarlais at the 2005 Cool Roofing Symposium in Atlanta entitled, *Are Ballasted Roof Systems Cool?*

Additional Information

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Abstract

Confusion remains over California's Title 24 cool roof requirements almost a year after it took effect. While installing a reflective roof is the obvious choice when it

comes to complying with Title 24, a closer reading of the document reveals there are other options available, such as the building envelope approach and whole building performance.