October 13, 2005

Jackalyne Pfannenstiel, Vice Chair
2008 Title 24
California Energy Commission
1516 9th Street, MS- 25
Sacramento, CA 95814-5504

Dear Ms. Pfannenstiel:

Please find accompanying this letter the Measure Information Template form for including "Cool Ballast" roofing systems in the 2008 Title 24. The template and additional data in the appendices will support this recommendation. As the 2008 Title 24 review process moves forward, we will be ready to answer any questions and supply additional information that may be needed by the committee to achieve approval for the recommendation inclusion in the standard.

Best regards,

Richard J. Gillenwater

Richard J. Gillenwater

CC: Elaine Hebert Bill Pennington

Measure Information Template – Cool Ballasted Roof System addition to the 2005 Title 24

2008 California Building Energy Efficiency Standards

Richard J. Gillenwater

October 13, 2005

CONTENTS

Overview

Description	This measure is for adding the Cool Ballasted Roof System to the definition of a Cool Roof. This measure defines the Cool Ballast System and allows for its use where a Cool Roof is called for.

Type of Change	**Mandatory Measure**	**In Subchapter 2, Section118, the Mandatory Measures for the Cool Ballast would be inserted just below the existing Exception in 118(i)1 and be defined as:**
	EXCEPTION to Section 118(i)1: For ballasted roof systems (as defined in SPRI/ANSI RP4), the ballast shall be made of either concrete pavers or stone, where the minimum stone size shall be number 4 (as defined in ASTM D448), and the ballast shall be applied onto the roof at a minimum rate of 15 pounds per square foot.	
	Prescriptive Requirement	**The Exception in Section 149(b)1B would have minor changes to bullets 1 and 2.**
	EXCEPTION to Section 149(b)1B: 1. The existing roof has a rock or gravel surface where the rock is smaller than number 4 stone (per ASTM (D448) or the stone is equal to or larger than #4 stone but applied at a rate less than 15 pounds per square foot, and 2. The new roof has rock or gravel surface as defined in 1, and	
	Compliance Option	**With the Cool Ballast roof defined as a Cool Roof, existing compliance options for Cool Roofs would apply to the Cool Ballast system.**
	Modeling	**There would be no change to the calculation procedures or assumptions used in making performance calculations. The Cool Roof values of Reflectivity of .70 and Emissivity of .75 would be used.**
	Other	**N/A**
	This does not change or modify or expand the scope of the Standard. It only offers a third option (first option is the Cool Roof with reflectivity minimum of .70 and emissivity minimum value of .75 and the second option of tile roofing with reflectivity minimum of .40 and emissivity minimum value of .75) for a roof system that functions as a Cool Roof. Tile roofs set presidencies for mass and profile as having a positive effect on energy savings as with the ballast system.	
Energy Benefits	**Offers the same or better energy savings as defined by a Cool Roof. The research data shows that ballast does not change with age as does Cool Roof single plies, metal roofs and coatings giving ballast a consistent performance therefore better energy savings over time.**	

Carlisle SynTec Incorporated
P.O. Box 7000 • Carlisle, PA 17013
Phone (toll free) 1-800-4-SYNTEC
www.carlisle-syntec.com

Non-Energy Benefits	Ballasted systems are Class A fire rated over all deck types as compared to the traditional BUR in California that in most cases are only Class B on wood decks.
Environmental Impact	➢ Reduced electrical use during installation for the system does not use fastener through out the roof as with BUR and MF single plies (no screw guns) or machines to weld sheets together (electric heat welders). ➢ Reduced VOC's for there is no asphalt to heat nor the moping of hot asphalt to glue all the BUR layers together releasing VOC's to the atmosphere.
Technology Measures	Measure Availability and Cost: EPDM is a prime membrane type used in ballasted systems but other membranes (TPO, modified bitumen) may also be used. EPDM is a third of the United State roofing market with major manufactures producing material in multiple plants. There is adequate capacity to supply the system. Ballast is also readily available. Useful Life, Persistence and Maintenance: EPDM manufactures offer up to 30-year fully system warranties on these roof systems. EPDM is the benchmark for all other materials for weathering. There are several studies that have been done showing EPDM membranes that have been exposed in the field for 26 years still meet the ASTM requirements for new material. The other materials, TPO and modified bitumen off, offer system warrants to 20-years.
Performance Verification	All major manufacturer's roofs are inspected before issuing the warranty. For the Cool Ballast design, the only item that would need to be added to the checklist is to assure compliance for the weigh of the ballast on the roof. Requirements: a tape measure, a bucket and a weight scale.
Cost Effectiveness	Ballasted systems are up to 50% less expensive than a single ply Cool Roof or modified bitumen. It is about 10% more expensive than the base BUR system used in CA, which consists of 2-plies and a cap sheet.
Analysis Tools	The existing tools in the 2005 Tile 24 are sufficient to cover the Cool Ballast design.
Relationship to Other Measures	N/A

Carlisle SynTec Incorporated
P.O. Box 7000 • Carlisle, PA 17013
Phone (toll free) 1-800-4-SYNTEC
www.carlisle-syntec.com

Methodology

There was a study done in 1997 at Georgia Tech looking at different methods to measure roof surface temperature. A number of different roofs were used for the measurements including ballasted EPDM, modified bitumen with white granule surface, gravel surface BUR, and exposed EPDM fully adhered system. Although there was no quantified data on the roof types, the coolest roof surfaces were the ballasted systems.

SPRI, Single Ply Roof Industry, initiated a study on Cool Single Ply Roofs to see how the reflectivity degraded over time and how that affected energy savings. Oak Ridge National Laboratory was commissioned to do the study. Ballasted roofs were included but only cursory data was collected on them. In the end, a review of the data from the ballasted systems showed some interesting facts indicating there was some energy saving far beyond what would be expected due to the stone's low reflectivity. Although the data showed positive results, the ballasted systems had not been quantified at installation making the data unreliable.

With the information generated from these two studies as a base, SPRI opted to pursue a study of the "Thermal Performance of Ballasted Roofing Systems" with Oak Ridge National Laboratory commissioned to conduct the investigation. This allowed consistent methodology between the original reflective study and the ballast study using the same control materials and data comparisons for repeatability. The study is still in progress but has completed 12 months of exposure. The controls in the ballast study are duplicating the results seen in the original study. The results from this study are the basis for the recommendation.

As far as life-cycle costs, the ballast system is one of the most cost efficient. Below give some indications of L-CC:

PRODUCT	COST/SQFT	LIFE EXPECTANCE	L-CC/SQFT/YR
BUR - CA	$1..00	10 YEARS	$0.100
COOL ROOF – SINGLE PLY	$1.70	20 YEARS	$0.085
BALLASTED SYSTEM	$1.20	20 YEARS	$0.060

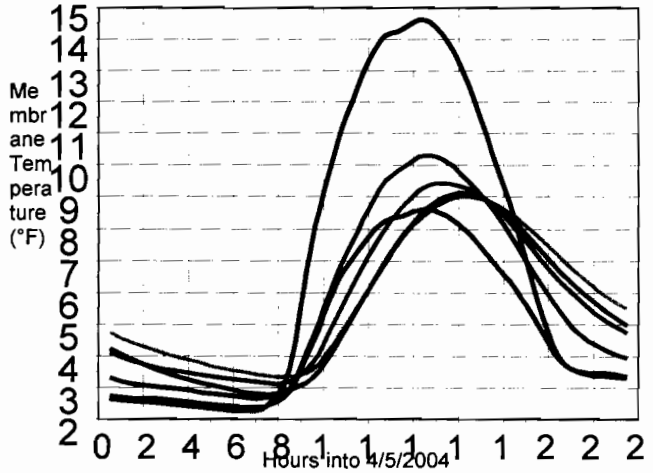
Analysis and Results

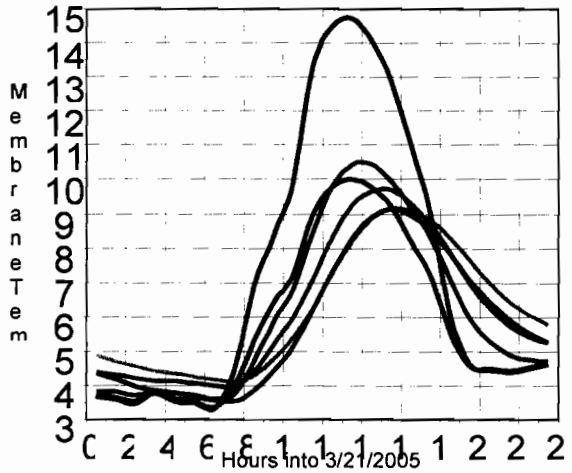
The ORNL "Thermal Performance of Ballast Roofing Systems" was conducted for twelve months. There were six (6) roof panels, each four-foot by four-foot, a size determine to be large enough to eliminate edge affects. The panels were instrumented with thermocouples and heat flux transducers to capture the live data as the roof went through the daily and

Carlisle SynTec Incorporated
P.O. Box 7000 • Carlisle, PA 17013
Phone (toll free) 1-800-4-SYNTEC
www.carlisle-syntec.com

year-long weather cycles. There were two control panels, a white TPO roof membrane and a black EPDM roof membrane. There were three stone ballast panels all using number 4-stone per ASTM D448 (smallest stone allowed on these systems) with one having a weight of 10-pounds per square foot (lowest weight allowed), 17-lbs/sqft, and 24-lbs/sqft. One panel had paver ballast at 24-lbs/sqft to match the stone for comparison and aid in modeling the system. The study was done on the Roof Thermal Research Apparatus (RTRA) at the Oak Ridge National Laboratory located in Oak Ridge, Tennessee

The data from the initial installation and at 12 months for membrane surface temperature are shown in the two charts:





The left chart shows the temperature profiles taken after initial installation with the black EPDM having the highest temperature and the white TPO the coolest at the maximum solar period. The 24-lb stone and paver were just above the white with the 17-lb and the 10-lb each at a higher temperature. The 10-lb stone ballast temperature was about half way between the high and low temperature.

The right chart shows the profiles after one year. At this point, the white TPO is warmer than the 17-lb stone ballast. It should also be noted that the ballast also delays the temperature rise up to three hours which in effect moves about 20 percent of the cool load into off peak hours reducing the cooling costs to the owner (peak rate hours being 12 to 6 PM). This is the base data for the recommendation. In the Appendix is the presentation given to the California Energy Commission that goes into greater detail on the results that lead to and support the recommendation. Besides the membrane temperature, the heat flux through

Carlisle SynTec Incorporated
P.O. Box 7000 • Carlisle, PA 17013
Phone (toll free) 1-800-4-SYNTEC
www.carlisle-syntec.com

the roofing system was captured showing the energy being transmitted through the roof system into the building. This data duplicated the membrane surface temperature. This is explained in the attached presentation.

Recommendations

The recommendation is to include the Cool Ballasted Roofing System as a Cool Roof in the 2008 Title 24 offering another option for a roof system that will supply all the benefits of a Cool Roof.

Material for Compliance Manuals – N/A

Bibliography and Other Research

Incropera, F.P., DeWitt, D.P. 1990. Fundamentals of Heat and Mass Treansfer. 3rd ed. John Wiley & Sons, New York. Taha, H., Sailor, D., Akbari, H. 1992. High-albedo materials for reducing building cooling energy use, LBL-31721, Lawrence Berkeley National Laboratory, Berkeley, CA

Gillenwater, R.J., Petrie, T.W., Miller, W.A., Desjarlais, A.O. 2005. "Are Ballasted Roof Systems Cool?" ORNL/TM-2005. Oak Ridge, TN, Oak Ridge National Laboratory. The Single-Ply Roofing Institute

Miller, W.A., Cheng, M.D., Pfiffner, A., and Byars, N. 2002. "The field performance of high-reflectance single-ply membranes exposed to three years of weathering in various U.S. climates." ORNL/TM-2002. Oak Ridge, TN, Oak Ridge National Laboratory. The Single-Ply Roofing Institute

Petrie, T.W., Desjarlais, A.O., Robertson, R.H., and Parker, D.S. 2000. Comparison of techniques for in-situ, non-damaging measurement of solar reflectance of low-slope roof membranes. Presented at the 14th Symposium on Thermophysical Properties and under review for publication in International Journal of Thermophysics, Boulder, CO: National Institute of Standards and Technology.

Reagab, J.A., Acklam, D.M. 1979. "Solar reflectivity of common building materials and its influence on the roof heat gain of typical southwestern US residences." Energy Building, Vol. 2., 237

Waterfill, M. and Downey, P. 1999. "Georgia State University Roof Temperature Study." Interface, March 1999. 10-13

Wilkes, K.E. 1989. Model for Roof Thermal Performance. ORNL/CON-274. Oak Ridge, TN, Oak Ridge National Laboratory

Carlisle SynTec Incorporated
P.O. Box 7000 • Carlisle, PA 17013
Phone (toll free) 1-800-4-SYNTEC
www.carlisle-syntec.com

Appendices

1. Presentation "Are Ballasted Roofs Cool ?" given to the California Energy Commission on August 16, 2005.

Carlisle SynTec Incorporated
P.O. Box 7000 • Carlisle, PA 17013
Phone (toll free) 1-800-4-SYNTEC
www.carlisle-syntec.com