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June 13, 2003

To: Chris Scruton (CEC)
From: Steve Wiel
Subject: **Cool Roof Colored Materials**: Monthly Progress Report for May 2003
CC: Hashem Akbari, Paul Berdahl, Andre Desjarlais, Bill Miller, Ronnen Levinson

A summary of the status of Tasks and Deliverables as of May 31, 2003 is presented in Attachment 1.

HIGHLIGHTS

- We have prepared a draft report summarizing our activities and analysis for Task 2.5.1.
- Based on our pigment characterization work, ultramarine blue is a useful pigment for cool coating formulation. For example, it can be used mixed with a cool yellow complex inorganic pigment (Ni-Sb-Ti-O) to make a dark gray color with solar reflectance above 0.4.
- CertainTeed Corporation (a leading manufacturer of asphalt shingle products) has requested entrance in our Cool Roofs Project. CertainTeed has expressed strong interest in the setup of a demonstration home in 2004.

Tasks

1.1 Attend Kick-Off Meeting
This Task is completed.

1.2 Describe Synergistic Projects
This Task is completed.

2.1 Establish the Project Advisory Committee (PAC)
This Task is completed.

2.2 Software Standardization
(No activity.)

2.3 PAC Meetings
The next PAC meeting (September 11, 2003) will be held at LBNL, Berkeley. The future PAC meetings will be held at the following locations: March 4, 2004 meeting: CEC, Sacramento; September 10, 2004 meeting: ORNL; March 3, 2005 meeting: at an

industrial partner facilities; and October 6, 2005 meeting: (the last one): CEC, Sacramento.

2.4 Development of Cool Colored Coatings

2.4.1 Identify and Characterize Pigments with High Solar Reflectance

Our May activity focused on finalizing the theory and writing up the results of our 50 pigment characterizations to date, in preparation for a June submission of our work to a journal; and preparing to characterize another 30 or so pigments, and to characterize the performance of mixtures.

A. We have simplified the theory in a manner than allows us to estimate and correct for interface reflections (e.g., those that occur when light passed from air to paint, or vice-versa) before we calculate the Kubekla-Munk absorption (K) and scattering (S) coefficients. This makes our computational algorithm more efficient and robust. We have identified a number of minor issues, such as the observation of nominally (though not truly) negative film absorptances, indicating that there are subtleties associated with the spectrometer measurements that must be corrected.

B. The pigment characterization measurements have identified ultramarine blue as a useful pigment for cool coating formulation. It is a weakly scattering ("non-hiding") pigment that has strong absorption in the 500 to 700 nm range. It appears to have less infrared absorption than either phthalo blue or cobalt aluminate blue. By mixing it with a cool yellow pigment we were able to make a dark grey (bluish tint) color with a solar reflectance of nearly 50%. Ultramarine blue is inexpensive and very durable; however, it does have some sensitivity to acids.

C. We have begun to disperse Ferro pigments into a clear acrylic base using our small roller mill. While this has produced acceptable paints, the process is somewhat slow, taking up to a day to disperse some of the more difficult pigments (e.g., IR blacks). An extensive technical discussion with Ray Wing (Ferro Corporation) has suggested that an efficient and reliable way to obtain high quality acrylic paints based on Ferro's cool pigments would to be to start from pre-dispersed Ferro pigment concentrates available from the Consolidated Color Corporation. Ken Loye (Ferro) has arranged to send us concentrates for a dozen Ferro cool colors.

2.4.2 Develop a Computer Program for Optimal Design of Cool Coatings

See Task 2.4.1. No major progress in May.

2.4.3 Develop a Database of Cool-Colored Pigments

(No activity.)

2.5 Development of Prototype Cool-Colored Roofing Materials

2.5.1 Review of Roofing Materials Manufacturing Methods

We have prepared a draft report summarizing our activities and analysis for Task 2.5.1. The report focuses on manufacturing methods for colored roofing granules, shingles, metal roofing, and clay rooftiles. Our industrial partners who participated in the Task are currently reviewing this report. In our review, we discovered that we also need to compile information on concrete rooftiles. In the upcoming months, we will make arrangements to visit a concrete rooftile plant.

2.5.2 Design Innovative Methods for Application of Cool Coatings to Roofing Materials

(No activity.)

2.5.3 Accelerated Weathering Testing
(No activity.)

2.6 Field-Testing and Product Useful Life Testing
CertainTeed Corporation has requested entrance in our Cool Roofs Project with the California Energy Commission. They are a leading manufacturer of asphalt shingle and other building products. Shiao, Ming L., principal research engineer at CertainTeed, is the company contact. He expressed strong interest in exposure of shingles and setup of a demonstration home in 2004.

The William Harrison Corporation built and shipped the exposure rack sets to the weathering sites in California. Reflectance and emittance measures were logged for the samples provided by BASF and MCA. ORNL is awaiting concrete tile samples from Monier LifeTile.

2.6.1 Building Energy-Use Measurements at California Demonstration Sites
ORNL personnel fabricated 2-ft by 2-ft sandwich test panels for use in measuring the temperatures and heat flow through the roof decks of the demonstration homes. The sandwich panels and decks of the demonstration homes will be made of 5/8-in oriented strand board (OSB). Each sandwich panel is made of two sections equaling the same thickness as the rest of the deck. The two panels sandwich thermocouples and a heat flux transducer (HFT) for measuring thermal performance of the roofs. Two spare thermocouples are included for measuring the surface temperature of the tile and the bulk air temperature between the tile and the roof deck. The panels are in calibration to correct for shunting that occurs because of the differences in thermal conductance of the HFT and the OSB.

2.6.2 Materials Testing at Weathering Farms in California
Initial reflectance and emittance measures were completed on the BASF painted polyvinylidene fluoride (PVDF) metal samples and the MCA clay tile samples.

Table 1. Reflectance measures for samples of painted (PVDF) metal provided by BASF.

	Regal White	Rawhide	Slate Blue	Brick red	Charcoal Gray	Hartford Green	Slate Bronze
Standard	0.69	0.44	0.17	0.20	0.12	0.09	0.12
CRCM	0.74	0.57	0.28	0.37	0.31	0.27	0.26
Difference	0.05	0.13	0.11	0.17	0.19	0.18	0.14

The reflectance data for the seven colors provided by BASF show that the darker the color the greater is the %-increase in reflectance induced by the CRCMs. The brick red, charcoal gray, hartford green and slate bronze had reflectance %-increase exceeding 90% of the standard colors. Regal white showed the least gain, which is expected because the reflectance of the standard white is already high at 69%. We are planning to check several of these samples using spectrophotometers available at ORNL and at LBNL.

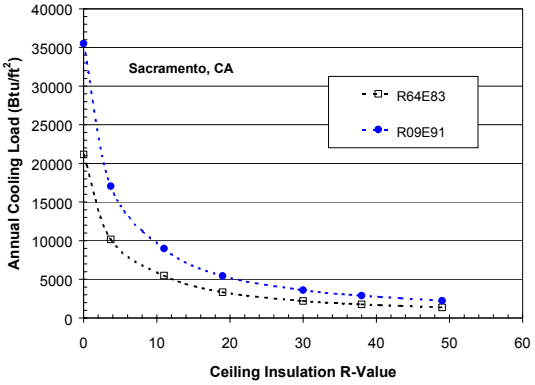
Jerry Vandewater sent Monier LifeTile's cement mixture to Shepherd Color Company for blending the CRCM into the concrete tiles. Tom Steger of Shepherd reported that Shepherd was successful in blending the CRCM pigments into a top layer, and stated Shepherd was able to match CRCM colors to the standard colors supplied by Monier.

The William Harrison Corporation built and shipped seven exposure rack sets to California. Shipment of the assemblies to the respective participating roofing manufacturers, Custom-Bilt, Steelscape, BASF, MCA and ELK will be received June 16 through 20, 2003. The participating manufacturers will install the exposure rack sets at

their facilities. ORNL personnel will install the two sets shipped to the California Irrigation Management Information System (CIMIS) sites located in Shasta and Imperial counties.

2.6.3 Steep-slope Assembly Testing at ORNL

The AtticSim computational tool was used this reporting period to calculate the roof temperatures and ceiling heat flows expected for different levels of ceiling insulation in an attic having a roof pitch of 4-in of rise for 12-in of run (18.4° slope). Simulations were made for an asphalt shingle having reflectance of 9% and emittance of 91% (i.e., R09E91) and compared to a more reflective product having R64E83, typical measures for clay tile and PVDF painted metal with CRCMs. Typical meteorological year (TMY2) weather data averaged over a ten-year period for Sacramento, CA were used as inputs to the model. The annual cooling load entering the roof was reduced almost 40% by using CRCMs in an attic having R-19 ceiling insulation, Fig. 1. The maximum summertime attic air temperature was 160°F for the attic with asphalt shingles as opposed to an attic air temperature of 128°F for the roof with CRCM. As expected increasing the level of ceiling insulation caused the cooling load to converge (Fig. 1); however, even with R-50 ceiling insulation the CRCMs have reduced the cooling load by about 40% of the heat entering the asphalt shingle roof with R-50 ceiling insulation.



2.6.4 Product Useful Life Testing

(No activity.)

2.7 Technology transfer and market plan

2.7.1 Technology Transfer

(No activity.)

2.7.2 Market Plan

(No activity.)

2.7.3 Title 24 Code Revisions

Levinson, Akbari, CEC, PG&E, Ely and Associates had many e-mail exchange discussing and fine-tuning the details of the code language for application of reflective low-sloped on non-residential buildings.

Management Issues

- None

Attachment 1

Project Tasks and Schedules (*Approved on May 16, 2002*)

Task	Task Title and Deliverables	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 05/31/2003
1	**Preliminary Activities**					
1.1	Attend Kick Off Meeting *Deliverables:* • Written documentation of meeting agreements and all pertinent information (**Completed**) • Initial schedule for the Project Advisory Committee meetings (**Completed**) • Initial schedule for the Critical Project Reviews (**Completed**)	5/16/02	5/16/02	6/1/02	6/10/02	100%
1.2	Describe Synergistic Projects *Deliverables:* • A list of relevant on-going projects at LBNL and ORNL (**Completed**)	5/1/02	2/1/02	5/1/02	5/1/02	100%
1.3	Identify Required Permits	N/A		N/A		
1.4	Obtain Required Permits	N/A		N/A		
1.5	Prepare Production Readiness Plan	N/A		N/A		
2	**Technical Tasks**					
2.1	Establish the project advisory committee *Deliverables:* • Proposed Initial PAC Organization Membership List (**Completed**) • Final Initial PAC Organization Membership List • PAC Meeting Schedule (**Completed)** • Letters of Acceptance	6/1/02	5/17/02	9/1/02		100%
2.2	Software standardization *Deliverables:* • When applicable, all reports will include additional file formats that will be necessary to transfer deliverables to the CEC • When applicable, all reports will include lists of the computer platforms, operating systems and software required to review upcoming software deliverables	N/A		N/A		

Project Tasks and Schedules (contd.)

Task	Task Title and Deliverables	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 05/31/2003
2.3	PAC meetings *Deliverables:* • Draft PAC meeting agenda(s) with back-up materials for agenda itemsFinal PAC meeting agenda(s) with back-up materials for agenda items Schedule of Critical Project ReviewsDraft PAC Meeting Summaries • Final PAC Meeting Summaries	9/1/02	6/1/02	6/1/05		33% (2/6)
2.4	Development of cool colored coatings					
2.4.1	Identify and Characterize Pigments with High Solar Reflectance *Deliverables:* • Pigment Characterization Data Report	6/1/02	6/1/02	12/1/04		~ 37%
2.4.2	Develop a Computer Program for Optimal Design of Cool Coatings *Deliverables:* • Computer Program	11/1/03		12/1/04		
2.4.3	Develop a Database of Cool-Colored Pigments *Deliverables:* • Electronic-format Pigment Database	6/1/03		6/1/05		
2.5	Development of prototype cool-colored roofing materials					
2.5.1	Review of Roofing Materials Manufacturing Methods *Deliverables:* • Methods of Fabrication and Coloring Report	6/1/02	6/1/02	6/1/03		~ 85%
2.5.2	Design Innovative Methods for Application of Cool Coatings to Roofing Materials *Deliverables:* • Summary Coating Report • Prototype Performance Report	6/1/02	6/1/02	12/1/04		< 5%
2.5.3	Accelerated Weathering Testing *Deliverables:* • Accelerated Weathering Testing Report	11/1/02	10/1/02	6/1/05		< 3%

Project Tasks and Schedules (contd.)

Task	Task Title	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 05/31/2003
2.6	Field-testing and product useful life testing					
2.6.1	Building Energy-Use Measurements at California Demonstration Sites *Deliverables:* • Demonstration Site Test Plan • Test Site Report	6/1/02	9/1/02	10/1/05		8%
2.6.2	Materials Testing at Weathering Farms in California *Deliverables:* • Weathering Studies Report	6/1/02	10/1/02	10/1/05		20%
2.6.3	Steep-slope Assembly Testing at ORNL *Deliverables:* • Whole-Building Energy Model Validation Presentation at the Pacific Coast Builders ConferenceSteep Slope Assembly Test Report	6/1/02	10/1/02	10/1/05		14%
2.6.4	Product Useful Life Testing *Deliverables:* • Solar Reflectance Test Report	5/1/04		6/1/05		
2.7	Technology transfer and market plan					
2.7.1	Technology Transfer *Deliverables:* • Publication of results in industry magazines and refereed journal articles • Participation in buildings products exhibition, such as the PCBC Brochure summarizing research results and characterizing the benefits of cool colored roofing materials	6/1/03	6/1/02	6/1/05		~ 5%
2.7.2	Market Plan *Deliverables:* • Market Plan(s)	5/1/05		6/1/05		
2.7.3	Title 24 Code Revisions *Deliverables:* • Document coordination with Cool Roofs Rating Council in monthly progress reports • Title 24 Database	6/1/02	5/16/02	6/1/05		~ 5%

Project Tasks and Schedules (contd.)

Task	Task Title	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 05/31/2003
VII	Critical Project Review(s) *Deliverables:* • Minutes of the CPR meeting					
XII (C)	Monthly Progress Reports *Deliverables:* • Monthly Progress Reports	6/1/02	6/1/02	6/1/05		33% (12/36)
XII (D)	Final Report *Deliverables:* • Final Report Outline • Final Report	3/1/05		10/1/05		
	Final Meeting *Deliverables:* • Minutes of the CPR meeting	10/15/05		10/31/05		