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July 15, 2004

To: Chris Scruton (CEC)
From: Steve Wiel
Subject: **Cool Roof Colored Materials**: Monthly Progress Report for June 2004
CC: Hashem Akbari, Paul Berdahl, Andre Desjarlais, Bill Miller, Ronnen Levinson

A summary of the status of Tasks and Deliverables as of June 30, 2004 is presented in Attachment 1.

HIGHLIGHTS

- The project team prepared and submitted an article on "Cool Roof Colored Materials" for the ECO Structure magazine.
- Review comments from the reviewers have been completed for the paper "*Special Infrared Reflective Pigments Make a Dark Roof Reflect Almost Like a White Roof*" to be presented in the upcoming THERM IX meeting.
- We continue to work with tile, granule, and shingle manufacturers to develop cooler products.
- We received two cool shingles to present to the developers of the demonstration houses for their selection.

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
Preparation for September PAC meeting is started.

2.4 Development of Cool Colored Coatings

2.4.1 Identify and Characterize Pigments with High Solar Reflectance
Our two pigment papers have been submitted to Solar Energy Materials & Solar Cells.

(The papers can be downloaded from
http://coriolis.lbl.gov/~hashem/share/PigmentPropertiesII(survey).pdf

http://coriolis.lbl.gov/~hashem/share/PigmentPropertiesI(model).pdf).

We are preparing a series of nonwhite paint mixtures to test the mixture model used in our software for design of high-reflectance coatings.

2.4.2 Develop a Computer Program for Optimal Design of Cool Coatings
We continue to develop a model and software predicting the reflectance of paint mixtures.

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 started revising the June 03 report to include the summary of manufacturing processes for cool-colored cement tiles that we received from Jerry Vandewater (MoneriLifetile) in February. We have abandoned our effort to visit a wood shake manufacturing plant or obtain literature information for this roofing product. With the revision of the report and submission for publication this task will be completed.

2.5.2 Design Innovative Methods for Application of Cool Coatings to Roofing Materials
We discussed with our partners the production of sample cool-colored shingles for demonstration. We received two cool shingles to present to the developers of the demonstration houses for their selection.

2.5.3 Accelerated Weathering Testing
We have completed a literature survey and located a few key papers providing limited data on the aging and weathering of asphalt shingles. (See discussion in Task 2.6.4 below.)

2.6 Field-Testing and Product Useful Life Testing
The negotiations with Mercy Housing have not been successful because the roofing contractor hired by Stephen Daues will not allow enough credit for the donation of materials by Elk Corporation.

The ESRA was made operable and data acquisition has commenced for the concrete and clay tiles under field study at ORNL.

2.6.1 Building Energy-Use Measurements at California Demonstration Sites
Stucco crews finished the exterior walls of the fourth demonstration house in Cavalli Hills. Rinky Dink Builders attached trim around the roof's fascia to finish the metal roof and they corrected problems with the roof mounted thermocouples on both C-style homes. All power instruments are not yet acquiring data and SMUD personnel are attempting repair. Also a modem was non functional for the third demonstration home. SMUD was able to trouble shoot the phone line–modem connection and data is now being downloaded from the A-style home with Hanson's concrete tile with CRCM coating. With the finishing work completed on the fourth house, ORNL personnel will

install the data acquisition system on the fourth demonstration house and will work with SMUD to make all power measurements operable.

Attic air temperatures are compared for the two A-style homes having concrete tile with and without cool-colored pigments. Solar reflectance of the tile having the Cool Tile IR Coating™ was about 0.41; tiles with the standard chocolate brown color had a reflectance of 0.08. The higher reflectance roof reduced the attic temperature about 5 to 15ºF around solar noon.

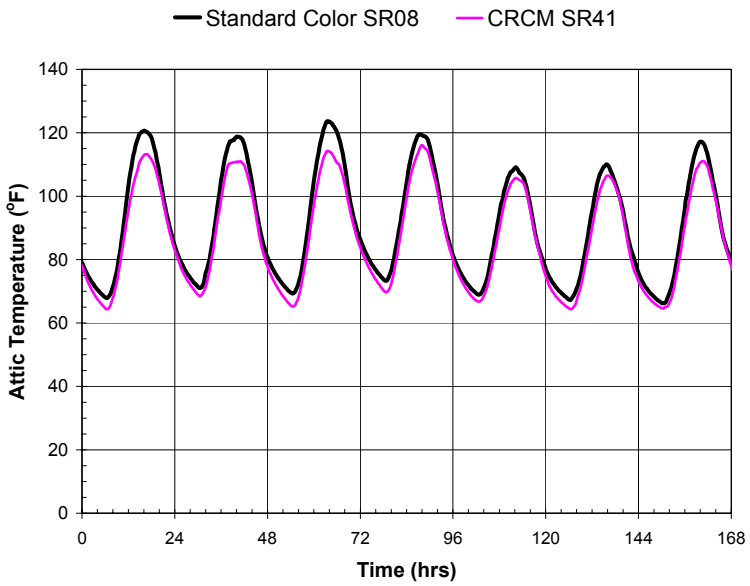

Figure 1. Attic temperatures measured during the week starting June 25, 04 for the two A-style homes with Hanson's low-profile concrete tile.

It is also interesting to note that the roof with the Cool Tile IR Coating™ had cooler attic temperatures during the early morning hours, implying that the cool-colored materials also helped reduce the amount of stored thermal energy in the concrete as compared to the adjacent house with concrete tile of standard color. This in-turn will cause the air-conditioning unit for the house with Cool Tile IR Coating™ to use less power than the adjacent home with concrete tile of standard color. Power measurements, once on-line, will help show this extra advantage of the cool-colored coatings as applied to tile roofs.

The reduction in attic temperature is a direct result of the reduction in heat penetrating the roof. Heat flux transducers embedded in the west facing roofs of both A-style homes show that the roof with Cool Tile IR Coating™ had less heat penetrating the roof as compared to the roof with standard color tile (Fig. 2). The greatest differences occur around solar noon, which may prove very beneficial for peak load reductions for the electric utilities.

Negotiations with Daues of Mercy Housing, the "Cool Team" and Elk's Marketing director John McCaskill were not successful, despite the fact that Elk provided two cool shingles to the developer for his selection. Daues stated Mercy Housing had subcontracted the roofing to a company that would not allow enough credit for donation of shingles from Elk. In short, the subcontractor signed an agreement and will not deviate

from the agreed upon quotation. Lou Hahn of Elk said he would help the "Cool Team" find another site for testing asphalt shingles with and without cool-colored materials.

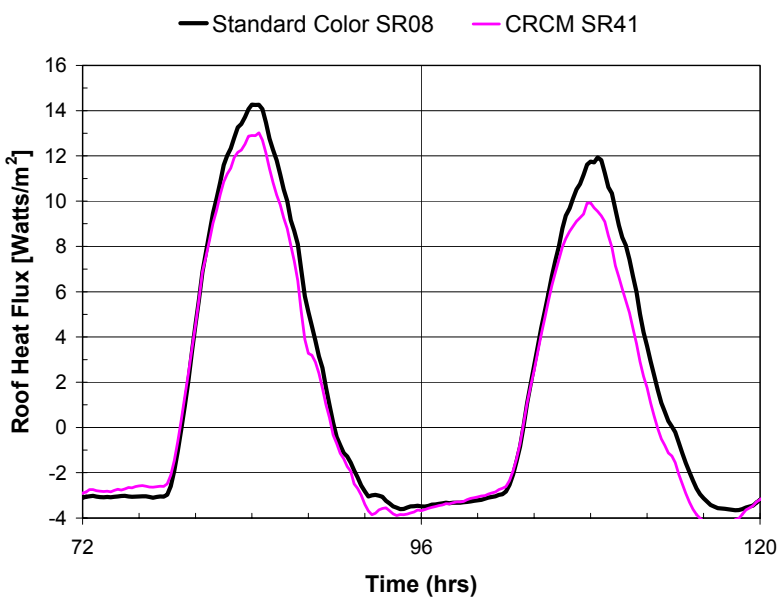

Figure 2. Heat flux penetrating the west facing concrete roof of each A-style home in Cavalli Hills.

2.6.2 Materials Testing at Weathering Farms in California

We measured the solar reflectances and thermal emittances of samples weathered at the Steelscape facility in Richmond, CA.

2.6.3 Steep-slope Assembly Testing at ORNL

Instrumentation and the data acquisition system (DAS) for the Envelope Systems Research Apparatus (ESRA) was made operable this period for the concrete and clay tile roofs under study at ORNL. A full week of data was acquired starting at June 25, 04 and results of the attic air temperature are shown in Figure 3. The control is an asphalt shingle roof having a surface averaged solar reflectance of about 0.08. Initial results show the two "S"-mission tile and the low-profile tile had the lowest attic air temperatures, these being the MCA clay, the Monierlifetile and the Hanson tile roofs. The Hanson tile roof has standard paint pigments and is the same concrete tile roof without cool colored pigments being tested at Cavalli Hills. The clay tile roof has the highest reflectance, 0.55, as compared to the Monierlifetile at 0.33 and Hanson at 0.08 reflectance. Surprisingly the slate tile roof on counter battens and the Eagle tile roof on battens had attic air temperatures just below the asphalt shingle control. It is expected that the air gap beneath these two tiles should support a cooler roof. Further data acquisition will be shown next period to better define the field trends.

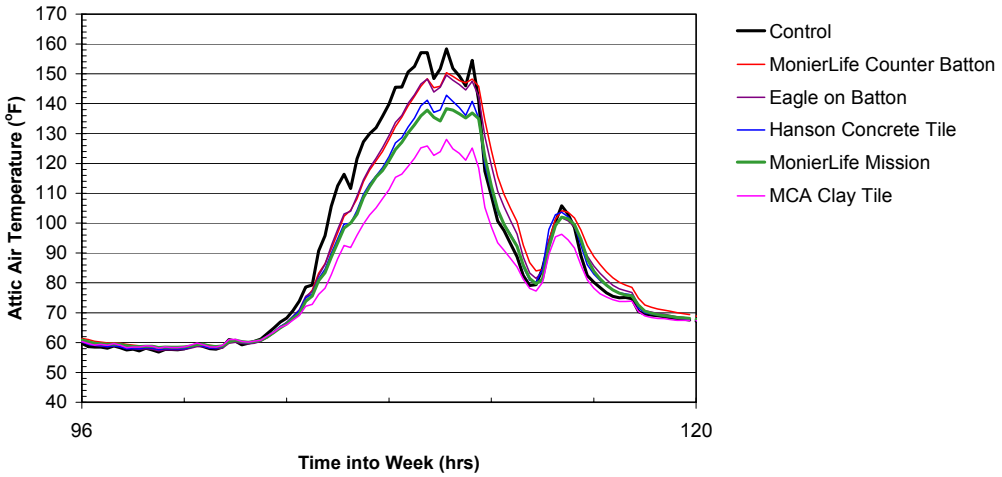

Figure 3. Attic air temperature measured under each of the tile roofs being field tested at ORNL.

2.6.4 Product Useful Life Testing

We have completed the literature survey of Task 2.5.3 above and located a few key papers providing limited data on the aging and weathering of asphalt shingles. Literature searches have shown that the degradation of asphalt, a key component in asphalt shingles, occurs because the asphalt gradually oxidizes. This oxidation makes the normally elastic and sticky material turn brittle. The oxygen for this process comes from the air, and the process is accelerated by the 300-400 nm UV in sunlight. We are planning to perform an experiment to see whether or not the oxidative degradation of asphalt shingles is accelerated by the higher temperatures experienced by less-reflective shingles. Prior work on asphalt roads has established that pavement lifetime can be shorter in hotter climates, but it does not appear to be known if the same is true for asphalt shingles. In July, we will consult with our asphalt shingle partners to refine our experimental design.

2.7 Technology transfer and market plan

2.7.1 Technology Transfer

The project team prepared and submitted an article on "Cool Roof Colored Materials" for the ECO Structure magazine.

Review comments from the “Project Team” and independent reviewers have been completed for the paper “*Special Infrared Reflective Pigments Make a Dark Roof Reflect Almost Like a White Roof.*”

Akbari and Desjarlais attended the ASHRAE June meeting in Nashville, TN.

2.7.2 Market Plan
(No activity.)

2.7.3 Title 24 Code Revisions
(No activity.)

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 06/30/2004
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 06/30/2004
2.3	PAC meetings *Deliverables:* • Draft PAC meeting agenda(s) with back-up materials for agenda items • Final PAC meeting agenda(s) with back-up materials for agenda items • Schedule of Critical Project Reviews Draft PAC Meeting Summaries • Final PAC Meeting Summaries	9/1/02	6/1/02	6/1/05		67% (4/6)
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		~ 95%
2.4.2	Develop a Computer Program for Optimal Design of Cool Coatings *Deliverables:* • Computer Program	11/1/03	11/1/03	12/1/04		~ 25%
2.4.3	Develop a Database of Cool-Colored Pigments *Deliverables:* • Electronic-format Pigment Database	6/1/03	7/1/03	6/1/05		~ 35%
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		~ 95%
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		~ 75%
2.5.3	Accelerated Weathering Testing *Deliverables:* • Accelerated Weathering Testing Report	11/1/02	10/1/02	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 06/30/2004
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		75%
2.6.2	Materials Testing at Weathering Farms in California *Deliverables:* • Weathering Studies Report	6/1/02	10/1/02	10/1/05		55%
2.6.3	Steep-slope Assembly Testing at ORNL *Deliverables:* • Whole-Building Energy Model ValidationPresentation at the Pacific Coast Builders ConferenceSteep Slope Assembly Test Report	6/1/02	10/1/02	10/1/05		60%
2.6.4	Product Useful Life Testing *Deliverables:* • Solar Reflectance Test Report	5/1/04	5/1/04	6/1/05		5%
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		~ 30%
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		~ 10%

Project Tasks and Schedules (contd.)

Task	Task Title	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 06/30/2004
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		64% (23/36)
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		