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

A summary of the status of Tasks and Deliverables as of February 28, 2003 is presented in Attachment 1.

HIGHLIGHTS

- The agenda for the March 2003 PAC meeting was finalized. We prepared draft presentation materials.
- The project team visited the Elk Corporation's shingle manufacturing plant in Shafter, CA

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 essentially completed. We have added two new members to the PAC.

2.2 Software Standardization
(No activity.)

2.3 PAC Meetings
The agenda for the PAC meeting on March 11, 2003 is finalized. A draft presentation material has been prepared for the PAC meeting.

2.4 Development of Cool Colored Coatings

2.4.1 Identify and Characterize Pigments with High Solar Reflectance
We characterized 7 more pigments (an infrared green and 6 metallics), bringing the total numbers of pigments studied to 58.

We further revised our "adapted Kubelka-Munk" theory to account for the effect of diffuseness (extent to which collimated light is diffused by passage through the film) on effective path length. That is, since the film path length for fully diffuse light is on average twice that for fully collimated light, the observed absorption and scattering coefficients for a given film depend on the light diffuseness. We also revised our theory for estimating diffuseness to recognize that the spectrometer's collimated beam is attenuated by forward and backward scattering. (The Kubelka-Munk theory assumes that all light is diffuse, and does not fully account for the forward scattering of the collimated light beam.) These two theoretical modifications have significantly improved the accuracy of our computed values of pigment properties, and may also yield insight into the directional nature of scattering by pigments.

2.4.2 Develop a Computer Program for Optimal Design of Cool Coatings

See Task 2.4.1. No major progress in February.

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

On February 19, Berdahl, Levinson, and Akbari visited the Elk Corporation's asphalt shingle factory in Shafter, CA. Lou Hahn (from Elk) and Chris Gross (from 3M) accompanied us on this visit. During the visit, we learned that very little of the black asphalt substrate (typically only a few percent) is permitted to show through the granule layer. This confirms our approach that the most effective way for designing cool shingles is to increase the reflectance of granules. It also appeared that the existing equipment for measuring the color of shingles may need to be expanded to afford capabilities for measuring reflectance in the near-infrared or solar spectra.

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

We prepared samples for the testing and analysis of the two-layer technique for applying cool pigments on roofing materials.

2.5.3 Accelerated Weathering Testing

(No activity.)

2.6 Field-Testing and Product Useful Life Testing

2.6.1 Building Energy-Use Measurements at California Demonstration Sites

ORNL and LBNL have selected Cavalli Hills, a new subdivision being built within the city limits of Sacramento, CA for demonstrating cool roof color materials in tile and painted metals. Cavalli Hills is located about a 30-minute drive east of the CEC headquarters. This is an excellent opportunity for demonstrating the energy benefits of cool roof color materials on residential roofs because of Cavalli Hills close proximity to the California Energy Commission and because the homes are typical of new house construction in CA.

A Memorandum of Understanding (MOU) was rewritten and submitted to the Sacramento Municipal Utility District (SMUD) and Mike Evans Construction. SMUD and Evans have agreed to coordinate work with ORNL for the setup and maintenance of data acquisition systems and instruments to be installed in the homes. We are awaiting receipt of the signed MOU document.

The architect working for Evans has developed 3 different house designs for Cavalli Hills. Footprints for the 3 home types are 1300, 1600 and 1900 square feet. Evans

states the homes will be placed with their length oriented north and south. Therefore we will instrument both east and west facing roofs to measure the morning and the afternoon performance of the CRCM roof systems.

Hanson Tile shipped its Portland cement and sand mixture to Ferro Corp. to blend a color in advance of fabricating the roof test materials. Todd Miller of Classic Products forwarded to Evans brochures of painted metal singles and shakes. Evans commented that he liked the selection of metal roof products.

2.6.2 Materials Testing at Weathering Farms in California

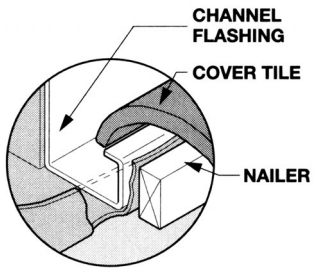
The William Harrison Corporation is building the exposure rack sets and will ship them with assembly instructions to the respective participating roofing manufacturers, Custom-Bilt, Steelscape, BASF, MCA and ELK. All participating manufacturers will install the exposure rack sets at their facilities. ORNL personnel will install the two sets shipped to the California Irrigation Management Information System (CIMIS) sites located in Shasta and Imperial counties.

Shephard Color Company and Jerry Vandewater of Monier LifeTile are developing the different color concrete tile samples with and without CRCM. BASF is supplying the painted metal samples straight from their production lines. BASF recently sent painted metal chips to Shepherd Color Company, Monier LifeTile and MCA for selecting similar colors as compared to the painted metal samples. BASF, Monier LifeTile and MCA will ship all their samples to ORNL for cataloging the initial reflectance and emittance measures. ORNL will place the samples in the "sure-grip" sub-assemblies and forward them to the respective sites for the start of exposure testing.

ORNL will ship some spare samples to LBNL to check the reflectance measures of CRCM made with the Device and Service reflectometer versus those made with the spectrophotometer.

2.6.3 Steep-slope Assembly Testing at ORNL

The configuration of concrete and clay tiles and painted metals selected for testing on the steep-slope assembly of the ERSA was reviewed with Jerry Vandewater of Monier Lifetile. All tiles whether direct nailed or installed on battens will have a venting occurring up along the height and transversely along the width of the test roofs. The Roof Tile Institute (RTI) had advised using a bead of foam between lanes to allow transverse venting effects only within a given test roof and not between test roofs. After further discussion however, we decided to use a parapet partition with channel flashing (see figure) between each test roofs to eliminate any effects of transverse airflow from one test roof to another.



RTI is keenly interested in better understanding the effects of venting between the roof deck and the clay and concrete tiles. The convection heat transfer in this space may be mixed, and is an important environmental heat transfer problem that can affect thermal performance of the roof. The mixed convection flow poses significant reductions in heat transfer penetrating the roof depending on whether the thermal buoyancy force is assisting or opposing the forced flow. Dr. Majid Keyhani and graduate students in the Mechanical Engineering Department of the University of Tennessee are working with W. Miller to develop a mathematical approach for numerically solving the Navier-Stokes and energy equation and validating the

approach against a well-controlled laboratory experiment and also against the field data acquired from the ESRA and the demonstration homes in Sacramento, CA. Our research team is initiating a parametric ranking within the expected variations in practice for the effects of upper and lower roof surface temperatures, channel aspect ratio, inlet air velocity, channel inclination and thermal mass of the tile.

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
(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 02/28/2003
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		98%
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 2/28/2002
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		15% (1/6)
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		~ 25%
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		~ 50%
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 02/28/2002
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		6%
2.6.2	Materials Testing at Weathering Farms in California *Deliverables:* • Weathering Studies Report	6/1/02	10/1/02	10/1/05		12%
2.6.3	Steep-slope Assembly Testing at ORNL *Deliverables:* • Whole-Building Energy Model Validation • Presentation at the Pacific Coast Builders Conference • Steep Slope Assembly Test Report	6/1/02	10/1/02	10/1/05		~ 11%
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		~ 3%
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 02/28/2002
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		25% (9/36)
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		