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To: Chris Scruton (CEC)
From: Steve Wiel
Subject: **Cool Roof Colored Materials**: Monthly Progress Report for January 2005
CC: Hashem Akbari, Paul Berdahl, Andre Desjarlais, Bill Miller, Ronnen Levinson

A summary of the status of Tasks and Deliverables as of January 31, 2005 is presented in Attachment 1. (Note the changes in the deliverables dates highlighted in yellow.)

HIGHLIGHTS

- We prepared an article for the *National Roofing* Magazine.
- We started planning for the sixth Project Advisory Committee meeting to be held on March 3, 2005 at the Custom-Bilt facilities in Chino, CA.
- BASF testing of cool pigments applied to painted metals and exposed to almost 10,000 hours of fluorescent UV light showed a slightly higher retention in gloss and improved fade resistance as compared to standard pigments of the same color.

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
Planning for the March 3, 2005 PAC meeting is underway. The meeting will be held at Custom-Bilt Facilities in Chino, California.

2.4 Development of Cool Colored Coatings

2.4.1 Identify and Characterize Pigments with High Solar Reflectance
Task Completed.

2.4.2 Develop a Computer Program for Optimal Design of Cool Coatings
We continue to improve the mixture model on which our coating formulation software is based, and to develop the optimization algorithm.

2.4.3 Develop a Database of Cool-Colored Pigments
Task Completed. We submitted to the CEC an HTML version of our pigment database that augments measured and computed solar spectral radiative properties with images of pigmented coatings, performance data from manufacturers, and technical commentary derived from our pigment papers. We made some formatting modifications to the database.

2.5 Development of Prototype Cool-Colored Roofing Materials

2.5.1 Review of Roofing Materials Manufacturing Methods
Task Completed.

2.5.2 Design Innovative Methods for Application of Cool Coatings to Roofing Materials
We continued working with manufacturers in developing cool shingle prototypes.

2.5.3 Accelerated Weathering Testing
We continue to collect references and perform literature searches on the topics of accelerated weathering and weathering mechanisms of roofing materials. The progress to date toward the respective reports will be reported at the forthcoming PAC meeting in Southern California.

2.6 Field-Testing and Product Useful Life Testing
The demonstration homes in Redding Calif. will be ready for commissioning the data acquisition systems April 4th 2005. Efforts made to impregnate cedar shakes with complex inorganic color pigments during the adding of fire retardants failed. A review was made of all field data collected for the Cavalli Hills site.

2.6.1 Building Energy-Use Measurements at California Demonstration Sites
Jerry Wagar of Ochoa and Shehan Inc. requested ORNL wait until the week of April 4th to complete setup for the two demonstration homes in Redding. Both houses have asphalt shingles installed (Fig. 1); however, the air-conditioning units will not be installed until mid-March, and our test plan calls for measuring the energy used to provide comfort cooling for the two homes.

Anthony Galo of Galchem Chemical Inc attempted to mix FERRO's inorganic pigments into the fire retardants added to cedar shakes. Results were not satisfactory. Galo observed the complex inorganic pigments to precipitate out of the fire retardant solution before he could pressurize and force the ingredients into the wood. Further testing showed the pigments to be aggressive precipitants, causing some of the fire retardant ingredients to also precipitate out of the solution. The pigments appear to have a strong ionic potential for certain compounds in the fire retardant, which puts in question long term leaching effects of the pigments on the treated shake, even if the pigments are applied as a paint coating. Galo believes that the differences in expansion and contraction of the wood and paint with cool-colored materials would have deleterious effects on the cedar shakes because the pigments may leach the retardants out of the cedar wood, especially when one considers that the ingredients were forced under hydrostatics into the wood and will by natural hydraulics tend to diffuse back out of the cedar.

The phenol resins in cedar gives the shake excellent weather ability upwards of almost 50 years. The porous internal structure of the wood strongly scatters light and even after 16 years of west coast weathering, cedar shakes have a solar reflectance of about 0.35

(see Aug., 04 report). Therefore, the economy of scale, and the incompatibility of the pigments with code approved fire retardants deters us from further pursuit of adapting complex inorganic color pigments to cedar shakes.


Figure 1. The pair of homes in Redding CA for demonstrating asphalt shingles with and without cool colored coatings.

Coding in Excel visual basic was programmed to read and write weeks of field data for making direct comparisons of the pairs of homes having concrete tile and painted metal roofs with and without cool colored coatings. All four homes have been online since August 04, and two of the houses (4979 and 4983 Mariah Place) have almost acquired a full year of data. Results are promising and continue to show the positive benefits of the reflective pigments. As example, coating the concrete tile roof with a 0.41 reflective layer produced an averaged 18.6% reduction in the heat transferred across the west facing tile roof. Similarly, a 36% drop in heat transferred across the metal roof was measured during the month of Sept., 04.

Table 1. The percentage drop in the heat flow measured across the south facing painted metal roofs and the west facing concrete tile roofs with cool colored coatings.

Week starting	Pair of Homes with and without cool colored roofs	
	Concrete tile roofs (% drop in $Q_{west\ roof}$)	Painted Metal Roofs (% drop in $Q_{south\ roof}$)
Sep. 3, 04	20.6	35.5
Sep. 10, 04	15.4	35.9
Sep. 17, 04	23.9	38.0
Sep. 24, 04	14.6	34.4
Average	**18.63**	**36.0**

Percentage is based on the reduction in roof heat transfer during the sunlit hours for a roof with cool colored roofs as compared to one without cool colored roofs.

2.6.2 Materials Testing at Weathering Farms in California

Concrete, clay and painted metal samples continue to be exposed in six different climate zones in Calif. Samples will be retrieved in March and some will be pulled and analyzed for the elemental composition of contaminants and for biomass.

2.6.3 Steep-slope Assembly Testing at ORNL

Concrete, clay and asphalt shingle samples continue to be exposed in the Steep-slope Assembly at ORNL.

2.6.4 Product Useful Life Testing

Masstones with and without cool colored pigments and of the same color were applied to polyvinylidene fluoride (PVDF) galvanized steel samples and exposed to QUV testing to observe differences in fading and gloss retention. A masstone represents the full color of a pigment. Samples were exposed to upwards of 10,000 hours of fluorescent UV light using the ASTM G154 protocol. The sample color, hours of exposure and the value of the total color change and the present reduction in gloss are shown in Figure 2. The total color difference (ΔE) is described in ASTM D 2244-02 (ASTM 2002), and is used by the paint industry to numerically identify variability in color over periods of time

The results show that pigment stability and discoloration resistance of the cool pigments are as good as those currently used in painted metal roof products (Fig. 2). The fade resistance of the cool colored blue and yellow masstones is much improved over the respective standard color. Blue, especially blue tints, are well known to fade; however, the cool colored masstone blue shows excellent fade resistance. The retention of gloss from the original color is also shown to verify performance of the larger sized cool pigments as compared to standard production pigments. A higher gloss paint is often preferred because it provides a homeowner greater wear and therefore reduced maintenance costs. The gloss retention findings are very important because, the larger the particle, the greater is its effect on film smoothness, which effects the scattering of light. The larger the size of a pigment particle the greater is the drop in gloss of a paint finish; however, the cool pigments actually show a slightly higher retention in gloss as compared to their counterparts and they therefore again perform as well as if not better than present production painted metals.

American Society for Testing and Materials (ASTM). 2002. Designation G 154-04: Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials. West Conshohocken, Pa.: American Society for Testing and Materials.

American Society for Testing and Materials (ASTM). 2002. Designation D2244-02: Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates. West Conshohocken, Pa.: American Society for Testing and Materials.

2.7 Technology transfer and market plan

2.7.1 Technology Transfer

We prepared an article for the *National Roofing* Magazine.

2.7.2 Market Plan

(No activity.)

2.7.3 Title 24 Code Revisions

Akbari continues working with PG&E and Energy Commission to develop a plan for code change proposal for sloped-roof residential buildings.

Management Issues

None.

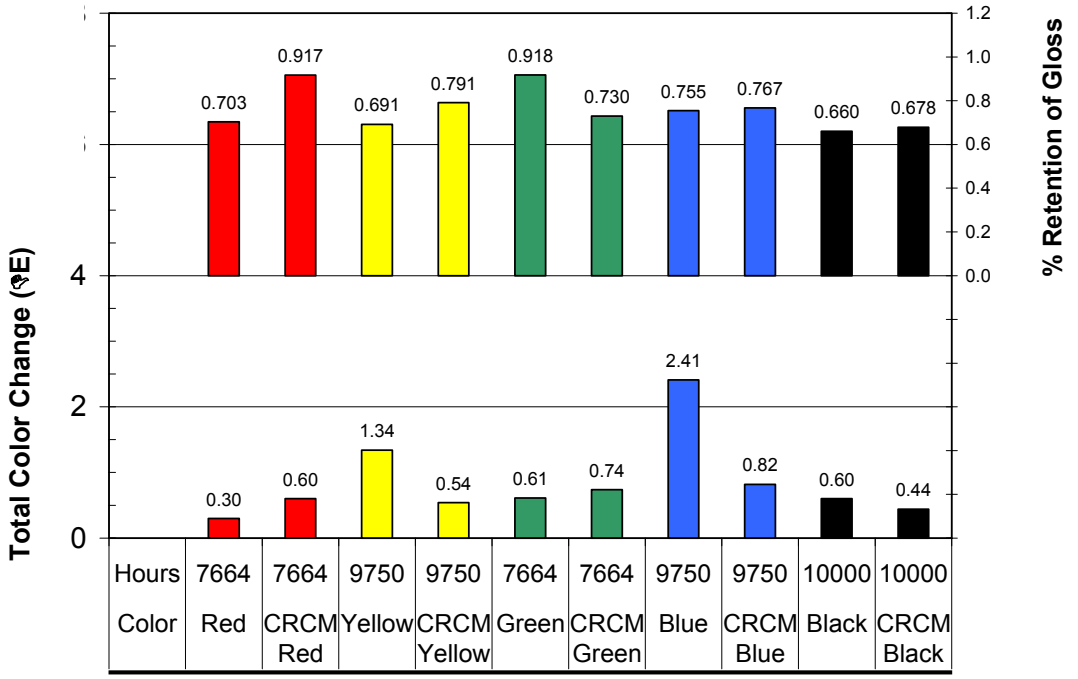

Figure 2. The total color change and the retention of gloss for masstones tested under fluorescent UV light using ASTM G154 protocol. (Data courtesy of BASF).

Attachment 1

Project Tasks and Schedules (*Approved on May 16, 2002; Revised schedules approved November 2004*)

Task	Task Title and Deliverables	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 1/31/2005
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 1/31/2005
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		83% (5/6)
2.4	Development of cool colored coatings					
2.4.1	Identify and Characterize Pigments with High Solar Reflectance *Deliverables:* • Pigment Characterization Data Report (**Completed)**	6/1/02	6/1/02	12/1/04 → 12/31/04		~ 99%
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 → 5/1/05		~ 90%
2.4.3	Develop a Database of Cool-Colored Pigments *Deliverables:* • Electronic-format Pigment Database (**Completed)**	6/1/03	7/1/03	6/1/05 → 12/31/04		~ 99%
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 (**Completed)**	6/1/02	6/1/02	6/1/03		~ 99%
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 → 5/1/05		~ 92%
2.5.3	Accelerated Weathering Testing *Deliverables:* • Accelerated Weathering Testing Report	11/1/02	10/1/02	6/1/05 → 10/1/05		~ 35%

Project Tasks and Schedules (contd.)

Task	Task Title	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 1/31/2005
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 → 10/1/06		85%
2.6.2	Materials Testing at Weathering Farms in California *Deliverables:* • Weathering Studies Report	6/1/02	10/1/02	10/1/05 → 10/1/06		70%
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		70%
2.6.4	Product Useful Life Testing *Deliverables:* • Solar Reflectance Test Report	5/1/04	5/1/04	6/1/05 → 10/1/05		40%
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		~ 85%
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		~ 40%

Project Tasks and Schedules (contd.)

Task	Task Title	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 1/31/2005
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		81% (29/36)
XII (D)	Final Report *Deliverables:* • Final Report Outline • Final Report	3/1/05 → 3/31/05		10/1/05 → 10/1/06		
	Final Meeting *Deliverables:* • Minutes of the CPR meeting	10/15/05		10/31/05		