



ERNEST ORLANDO LAWRENCE  
BERKELEY NATIONAL LABORATORY

Stephen Wiel, Head  
Energy Analysis Department  
Environmental Energy Technologies Division

MS 90R4000  
1 Cyclotron Road  
Berkeley, CA 94720-8136

Tel: 510-486-5396  
Fax: 510-486-6996  
e-mail: Swiel@lbl.gov

---

October 23, 2003

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

A summary of the status of Tasks and Deliverables as of September 30, 2003 is presented in Attachment 1.

## HIGHLIGHTS

- We prepared and presented a draft paper characterizing 83 single-pigment paints to our industrial partners and Project Advisory Committee at meetings held on September 10 and 11, respectively.
- We prepared and measured 1:4 and 1:9 tints (mixtures with white) of nearly all the acrylic-based paints received to date.
- A report reviewing roofing materials manufacturing methods was prepared and posted on the project website ([CoolColors.LBL.gov](http://CoolColors.LBL.gov)).
- The third project advisory committee (PAC) meeting was held at LBNL on September 11, 2003.
- We shared a preliminary version of our pigment property database with our industrial partners.
- Progress continued on the demonstration homes being built by Evans Construction at Cavalli Hills. Sacramento. Evans has two houses ready for installation of Hacienda concrete tile (H 409) donated by Hanson Roof Tile that is already at the site. "Country Manor Shakes" by Custom-Bilt Metals will be installed on the two homes adjacent the two homes covered with Hanson's concrete tile as the project progresses.
- A brochure was developed to help Evans explain to potential homeowners the benefits of cool colored pigments and the special tests ORNL will perform at no cost to them to check the thermal performance of their residences (see Attachment 2).

- Exposure rack systems were installed and painted metal and clay tile roof samples are now under field test at the Materials Testing Weathering Farms at Custom-Bilt, Steelscape, BASF, MCA, ELK, McArthur Farms and the California Irrigation Management Information System (CIMIS).
- The Shepherd Color Company worked with MonierLife Tile and made improved concrete tile samples for testing. The American Roof Tile and US Tile are also planning to place concrete and clay roof tiles with cool colored coatings for weathering at the seven CA exposure sites.

## 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 third PAC meeting was held on September 11. The project team met with the industrial partners prior to the PAC meeting on the afternoon of September 10. The agenda for the PAC meeting, the minutes of the meeting, the list of attendants, and the presentation material for the PAC meeting are available for viewing on the project web site ([CoolColors.LBL.gov](http://CoolColors.LBL.gov)).

2.4 Development of Cool Colored Coatings

2.4.1 Identify and Characterize Pigments with High Solar Reflectance

We have characterized paint films prepared from 15 Shepherd "cool" pigments received in the form of pre-dispersed concentrates (courtesy Shepherd Corporation).

We prepared and measured 1:4 and 1:9 tints (mixtures with white) of nearly all the acrylic-based paints received to date.

We completed (for purposes of our single-pigment-paint characterizations) the model used to compute Kubelka-Munk absorption and scattering coefficients  $K$  and  $S$  from measurements of film transmittance and film reflectance over various backgrounds. We started to document our efforts.

We have prepared a draft paper summarizing our pigment characterization work to date. The paper includes presentation and discussion of theory, model performance, and spectral descriptions of the optical properties of 83 single-pigment paint films. This draft is being reviewed and revised.

We presented our draft paper characterizing 83 single-pigment paints to our industrial partners and Project Advisory Committee at meetings held on September 10 and 11. We will incorporate their feedback in the final version of the paper.

2.4.2 Develop a Computer Program for Optimal Design of Cool Coatings  
(No activity.)

2.4.3 Develop a Database of Cool-Colored Pigments

This task was started on July 1, 2003 by developing a format for the database. This format was presented and discussed in our September 10 and 11 meetings with our industrial partners and PAC members.

We shared a preliminary version of our pigment property database with our industrial partners. Its current form is a ZIP archive of tab-delimited text files, one file per single-pigment paint. Each file details the measured and computed solar spectral optical properties of a pigment, such as film reflectance, film transmittance, film absorptance, scattering coefficient, and absorption coefficient.

2.5 Development of Prototype Cool-Colored Roofing Materials

2.5.1 Review of Roofing Materials Manufacturing Methods

The “Roofing Materials Manufacturing Methods” draft report was prepared and presented at the PAC meeting (the report is posted on the web). The representatives from cement roof tile and cedar shake roof manufacturers requested that the report be expanded to include these roofing materials. We are arranging visits to cement roof tile and cedar shake roof-manufacturing plants and will expand the current draft report.

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

We provided additional data on the efficacy of ultramarine blue as a cool pigment to some of our industrial partners. They, in turn, emphasized that the limited stability of this pigment is a major drawback, even in silica-coated versions of the pigment.

We continued our discussions regarding the application to the two-layered technique and novel cool pigments with a few of our industrial partners. We expect to receive samples of novel roofing granules and at least two types of coated roof tiles in the near future.

2.5.3 Accelerated Weathering Testing  
(No activity.)

2.6 Field-Testing and Product Useful Life Testing

Shepherd Color Company made concrete tile samples with cool colored pigments for MonierLife Tile. The samples were delivered to ORNL and will be placed at the seven weathering sites during the first recall for logging reflectance and emittance measures. American Roof Tile and US Tile want to expose concrete and clay samples at the seven field sites. Mike Evans has three homes partially constructed in Cavalli Hills off Sunrise Boulevard in Sacramento, CA. Evans selected Hanson’s Hacienda tile (H 409) for the two ‘A’ style homes. The H409 is a dark brown low-profile concrete tile. ORNL personnel will install instruments and wiring to the data acquisition systems for each of the three houses the last week of October. A brochure was developed to help Evans explain to potential homeowners the benefits of cool colored pigments and the special tests ORNL will perform at no cost to them to check the thermal performance of their residences (see Attachment 2).

2.6.1 Building Energy-Use Measurements at California Demonstration Sites

Miller and Scruton visited the demonstration homes at Cavalli Hills, Sacramento following the September 11, 2003 Project Advisory Committee meeting. Mike Evans of Evans Construction (second from right in the background, Fig. 1) met with Willem Boss and David Bisbee of SMUD (first and third from right, Fig. 1), with the CEC project manager Chris Scruton (fourth from right, Fig. 1) and with W. Miller of ORNL. As of this writing three of four demonstration homes are partially



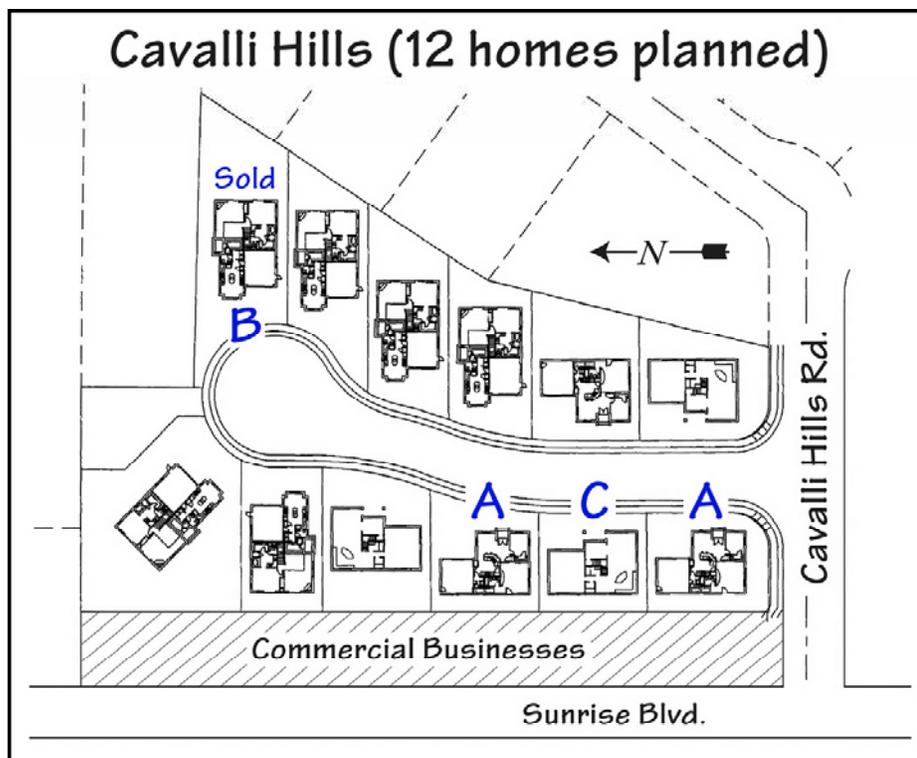
Fig. 1. ORNL, SMUD and the CEC with Evans Const.

constructed with 5/8" oriented strand board (OSB) nailed to the roof rafters.

W. Miller and J. Atchley of ORNL had previously visited Evans in August at the Cavalli Hills subdivision and reviewed placement of instrumented oriented strand board (OSB) sandwich panels in the roofs of the demonstration homes. The instrumented panels are made of 5/8-in oriented strand board and are equipped with a calibrated heat flux transducer and thermometry for measuring surface, air gap, deck and the underside deck temperatures in the roofs. Calibration of the heat flux transducers showed a slight but linear drop in sensitivity as the temperature of the OSB was increased from 40° to 120°F (i.e., temperatures typically observed by Parker in roof decks field tested at Ft. Myers, FL). Evans stated that his construction crew would cut the instrumented (OSB) sandwich panels supplied by ORNL into the three roofs.

Hanson Roof Tile donated their low-profile Hacienda tiles for the two 'A' style homes in Cavalli Hills (Figure 2). The tiles are a model H409 having standard brown color pigments. Materials are on site at Cavalli Hills as of this writing, and Dynamic Roofing will install the concrete tile. Once installed, Joe Riley of American Roof Tile will apply four topcoats to one of the two tile roofs. The topcoat contains cool colored pigments and will boost the reflectance of the tile to almost 45%. Riley developed the technique through funding from California's Energy Innovation Small Grants program. The technique applies enough of Ferro Corp.'s cool colored pigments to develop about a 6-mil thick painted surface that is highly reflective and opaque to infrared radiation. Ken Loye of Ferro Corp. had developed a slurry coat application; however, Loye agreed that the topcoat application developed by American Roof Tile is the most expedient process for getting the job done. Hanson and American Roof Tile will provide Evans a ten-year warranty on the coating. The labor and material for installing the topcoats will be covered by ORNL.

Custom-Bilt Metals will supply Evans with "Country Manor Shake" with and without cool colored pigments. Painted metal shakes will be installed on the two 'C' style homes adjacent to the two 'A' style homes covered with Hanson's concrete tile. Rinkydink Builders will install the painted metal roof systems. Evans Construction has one 'C' style home ready for roof placement, while ground breaking has already started for the second 'C' style home.



**Figure. 2. Plan view of the A, B and C style homes being built in Cavalli Hills subdivision, Sacramento, Ca.**

Willem Boss and W. Miller developed a common data acquisition system (DAS) for measuring performance of the insulated concrete form (ICF) wall, cool-colored roofs and HVAC. All DAS equipment has been calibrated and checked for proper operation. ORNL personnel are scheduled to run instrument wiring the last week of October. Evans Construction prefers minimal intrusions from DAS and monitoring equipment. He wants potential homebuyers to be enthusiastic about their new home, and not dissatisfied with unsightly DAS equipment. Therefore ORNL has requested Evans to install a 1-in PVC pipe into the exterior foam of the ICF wall. The pipe will run from the attic to about 3-ft above ground level and will be used as a conduit for running instrument wires from the attic to the DAS. Evans plans to finish the exterior walls with stucco and therefore the 1-in PVC pipe will be hidden; it is being embedded in the wall.

#### 2.6.2 Materials Testing at Weathering Farms in California

Shepherd Color Company sent a chemist from their technical service lab to MonierLife Tile's Rialto, CA plant to help expedite manufacture of more reflective concrete tile samples. Shepherd Color Company shipped the improved concrete tile samples to ORNL for reflectance and emittance measurements. ORNL will place the samples at the seven CA exposure sites after the first recall of field samples for documenting surface property measurements.

Joe Riley of the American Roof Tile Company and Brad Heath of US Tile are both preparing samples of concrete and clay tiles for the weathering study of cool colored pigments. ORNL will also place these samples in the seven field sites.

#### 2.6.3 Steep-slope Assembly Testing at ORNL

After the September. 11, 2003 PAC meeting, Jerry Vandewater of MonierLife Tile and the Roof Tile Institute (RTI) encouraged W. Miller to contact Dr. Nigel Cherry of the

Lafarge Roofing Technical Center in West Sussex, England. The Lafarge Technical Center has developed a simulation tool for predicting the condensation of moisture in the air gap of vented roof tile. Miller and Cherry discussed potential synergistic opportunities for collaborative work on the venting of batten and counter-batten construction. 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

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 several e-mail exchanges discussing and fine-tuning the details of proposed Title 24 code language for application of reflective low-sloped on non-residential buildings.

### **Other Activities**

- Drs Tammy Elkins and Bill Herron from DuPont Central Research and Development visited LBNL and discussed development and marketing of cool-colored roofing materials.

### **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 09/30/2003
1	<b>Preliminary Activities</b>					
1.1	Attend Kick Off Meeting <i>Deliverables:</i> <ul style="list-style-type: none"> <li>Written documentation of meeting agreements and all pertinent information (<b>Completed</b>)</li> <li>Initial schedule for the Project Advisory Committee meetings (<b>Completed</b>)</li> <li>Initial schedule for the Critical Project Reviews (<b>Completed</b>)</li> </ul>	5/16/02	5/16/02	6/1/02	6/10/02	100%
1.2	Describe Synergistic Projects <i>Deliverables:</i> <ul style="list-style-type: none"> <li>A list of relevant on-going projects at LBNL and ORNL (<b>Completed</b>)</li> </ul>	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	<b>Technical Tasks</b>					
2.1	Establish the project advisory committee <i>Deliverables:</i> <ul style="list-style-type: none"> <li>Proposed Initial PAC Organization Membership List (<b>Completed</b>)</li> <li>Final Initial PAC Organization Membership List</li> <li>PAC Meeting Schedule (<b>Completed</b>)</li> <li>Letters of Acceptance</li> </ul>	6/1/02	5/17/02	9/1/02		100%
2.2	Software standardization <i>Deliverables:</i> <ul style="list-style-type: none"> <li>When applicable, all reports will include additional file formats that will be necessary to transfer deliverables to the CEC</li> <li>When applicable, all reports will include lists of the computer platforms, operating systems and software required to review upcoming software deliverables</li> </ul>	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 09/30/2003
2.3	<p>PAC meetings <i>Deliverables:</i></p> <ul style="list-style-type: none"> <li>• Draft PAC meeting agenda(s) with back-up materials for agenda items</li> <li>• Final PAC meeting agenda(s) with back-up materials for agenda items</li> <li>• Schedule of Critical Project Reviews</li> <li>• Draft PAC Meeting Summaries</li> <li>• Final PAC Meeting Summaries</li> </ul>	9/1/02	6/1/02	6/1/05		50% (3/6)
2.4	Development of cool colored coatings					
2.4.1	<p>Identify and Characterize Pigments with High Solar Reflectance <i>Deliverables:</i></p> <ul style="list-style-type: none"> <li>• Pigment Characterization Data Report</li> </ul>	6/1/02	6/1/02	12/1/04		~ 55%
2.4.2	<p>Develop a Computer Program for Optimal Design of Cool Coatings <i>Deliverables:</i></p> <ul style="list-style-type: none"> <li>• Computer Program</li> </ul>	11/1/03		12/1/04		
2.4.3	<p>Develop a Database of Cool-Colored Pigments <i>Deliverables:</i></p> <ul style="list-style-type: none"> <li>• Electronic-format Pigment Database</li> </ul>	6/1/03	7/1/03	6/1/05		~ 7%
2.5	Development of prototype cool-colored roofing materials					
2.5.1	<p>Review of Roofing Materials Manufacturing Methods <i>Deliverables:</i></p> <ul style="list-style-type: none"> <li>• Methods of Fabrication and Coloring Report</li> </ul>	6/1/02	6/1/02	6/1/03		~ 95%
2.5.2	<p>Design Innovative Methods for Application of Cool Coatings to Roofing Materials <i>Deliverables:</i></p> <ul style="list-style-type: none"> <li>• Summary Coating Report</li> <li>• Prototype Performance Report</li> </ul>	6/1/02	6/1/02	12/1/04		~ 10%
2.5.3	<p>Accelerated Weathering Testing <i>Deliverables:</i></p> <ul style="list-style-type: none"> <li>• Accelerated Weathering Testing Report</li> </ul>	11/1/02	10/1/02	6/1/05		<5%

**Project Tasks and Schedules (contd.)**

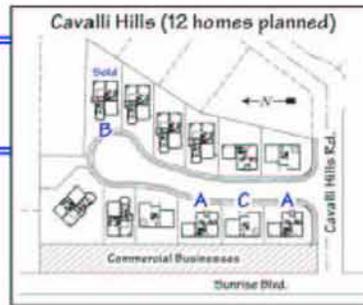
Task	Task Title	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 09/30/2003
2.6	Field-testing and product useful life testing					
2.6.1	Building Energy-Use Measurements at California Demonstration Sites <i>Deliverables:</i> <ul style="list-style-type: none"> <li>• Demonstration Site Test Plan</li> <li>• Test Site Report</li> </ul>	6/1/02	9/1/02	10/1/05		35%
2.6.2	Materials Testing at Weathering Farms in California <i>Deliverables:</i> <ul style="list-style-type: none"> <li>• Weathering Studies Report</li> </ul>	6/1/02	10/1/02	10/1/05		45%
2.6.3	Step-slope Assembly Testing at ORNL <i>Deliverables:</i> <ul style="list-style-type: none"> <li>• Whole-Building Energy Model Validation Presentation at the Pacific Coast Builders Conference</li> <li>• Steep Slope Assembly Test Report</li> </ul>	6/1/02	10/1/02	10/1/05		20%
2.6.4	Product Useful Life Testing <i>Deliverables:</i> <ul style="list-style-type: none"> <li>• Solar Reflectance Test Report</li> </ul>	5/1/04		6/1/05		
2.7	Technology transfer and market plan					
2.7.1	Technology Transfer <i>Deliverables:</i> <ul style="list-style-type: none"> <li>• Publication of results in industry magazines and refereed journal articles</li> <li>• Participation in buildings products exhibition, such as the PCBC Brochure summarizing research results and characterizing the benefits of cool colored roofing materials</li> </ul>	6/1/03	6/1/02	6/1/05		~5%
2.7.2	Market Plan <i>Deliverables:</i> <ul style="list-style-type: none"> <li>• Market Plan(s)</li> </ul>	5/1/05		6/1/05		
2.7.3	Title 24 Code Revisions <i>Deliverables:</i> <ul style="list-style-type: none"> <li>• Document coordination with Cool Roofs Rating Council in monthly progress reports</li> <li>• Title 24 Database</li> </ul>	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 09/30/2003
VII	Critical Project Review(s) <i>Deliverables:</i> <ul style="list-style-type: none"> <li>Minutes of the CPR meeting</li> </ul>					
XII (C)	Monthly Progress Reports <i>Deliverables:</i> <ul style="list-style-type: none"> <li>Monthly Progress Reports</li> </ul>	6/1/02	6/1/02	6/1/05		44% (16/36)
XII (D)	Final Report <i>Deliverables:</i> <ul style="list-style-type: none"> <li>Final Report Outline</li> <li>Final Report</li> </ul>	3/1/05		10/1/05		
	Final Meeting <i>Deliverables:</i> <ul style="list-style-type: none"> <li>Minutes of the CPR meeting</li> </ul>	10/15/05		10/31/05		

## Mike Evans Building Energy Efficient Homes For You

Evans Construction  
 EL Dorado Hills, CA 95762  
 Phone (916) 939 1854  
 Fax (916) 939 3419

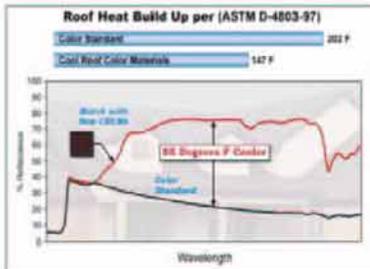
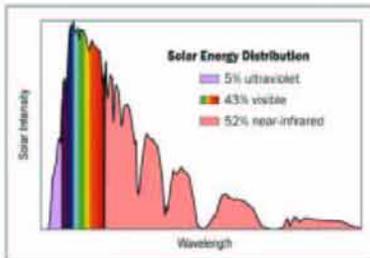


### COOL ROOF COLOR MATERIALS (CRCMs)

Most painted roofs today have a reflectance of about 10-20%, but special paint made using Cool Roof Color Materials can give you a much higher reflectance of almost 60%. A roof covered by this special paint absorbs less solar energy and can save nearly 20% of your air conditioning costs.

FERRO Corp. and the Shepherd Color Company developed the Cool Roof Color Materials to look dark in color even though they reflect most of the sun's energy.

How can these dark roofs reflect as much or more energy than a white roof? The sun's radiation consists of



ultraviolet, visible, and infrared energy. Our eyes can only see the visible region. The visible light that is reflected from an object determines the color of that object. White roofs reflect most of the visible light (which mixes together to look white to our eyes), but over half of the sun's energy is contained in the infrared region, which isn't visible

to our eyes. Because we can't see this energy, we can reflect it away from the roof without changing the roof's color.

### Advantages of Cool Roof Color Materials

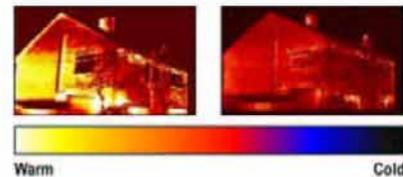
- Better fade resistance than standard colors
- Reflect more sunlight and stay cooler
- Lower utility bill for cooling the house
- Architectural appeal

### Insulated Concrete Form Walls

Oak Ridge National Laboratory and the Florida Solar Research Center independently proved that insulated concrete form wall construction reduces seasonal cooling energy. These walls save energy in two ways. First they have a higher thermal resistance (R-value) than many other types of walls. Second, they tend to store energy, so that regular day and night temperature swings can help cool the house in summer and warm the house in winter.

### Special Testing

The Sacramento Municipal Utility District is working with Evans Construction because they want to collect thermal performance data for insulated concrete form walls in Sacramento. The California Energy commission and two national laboratories, Oak Ridge National Lab and Lawrence Berkeley National Lab, are interested in knowing the performance of the Cool Roof Color Materials. So it makes good sense to work together in one project. Oak Ridge will make thermal scans of the roofs and walls. In these scans, cold surfaces show as black while the hottest surfaces are orange, red or white in color. The house with ICF walls on the right show lower wall temperatures than the frame construction house on the left, and therefore has lower heat losses.



Air leakage affects the thermal performance of a home, and can account for 30% or more of your home's utility bill. Oak Ridge will conduct blower door and duct testing to determine the natural infiltration rate of the house and duct system. Uncontrolled air leakage can result in high fuel bills and moisture damage.

