A Study of the Energy Savings that can Occur when Using Thermilate Solar Reflective Paint on Irradiated Building Walls

For Thermilate

By

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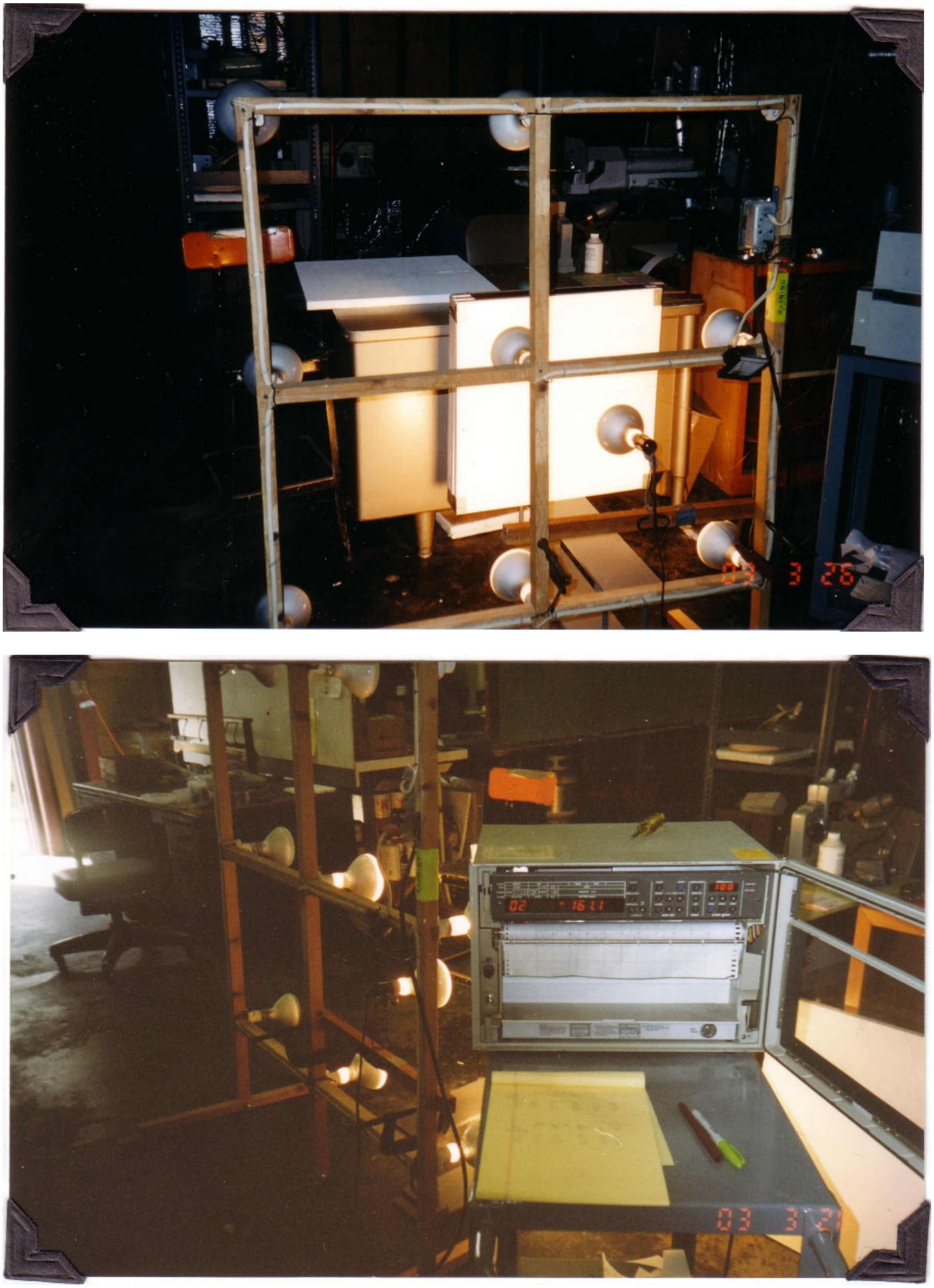
GEOSCIENCE LTD 6260 Marindustry Drive San Diego, California 92121 Photograph of the solar lamp array and Thermilate painted wall panel



Photograph of the millivolt recorder and solar lamp array

I. INTRODUCTION

Geoscience was requested by Mr. David Page to perform several tasks relative to the energy savings that result when using Thermilate paint on the outside of the building envelope. One task dealt with comparative outer wall panel surface temperature and corresponding heat flux measurements for the solar irradiated panels painted with Thermilate paint as well as with ordinary paint. A second task involved determining the additional panel thermal resistances that would have to be added to insulated wall systems painted with ordinary paint to yield the low thermal heat fluxes through a building wall when using Thermilate paint on the outer surface. The last task that was requested involved defining a mathematical thermal wall model so that the equations can be used to calculate wall thermal performance characteristics when system parameter changes occur.

II. MATHEMATICAL THERMAL WALL OR ROOF MODEL

An elementary model has been used which gives the steady state wall or roof temperature and the required heat removal to maintain a given room temperature when the outside weather conditions are known.
The heat balance for this system is,

$$\alpha \bar{G} = (h_c + h_r)(t - t_0) + \frac{t - t_i}{(R_r + R_i)}$$

where

α , solar absorptivity of the wall or roof surface

$\bar{G}$, mean solar heat input, Btu/hr ft^2

h_c , outside convective heat transfer conductance for the wall or roof, Btu/hr ft^2 °F

h_r , outside radiative heat transfer conductance for the wall or roof, Btu/hr ft^2 °F

t , irradiated wall or roof temperature, °F

t_0 , invariant outside ambient air temperature, °F

t_i , invariant interior air temperature of building, °F

t_b , backside (unexposed) wall or roof temperature, °F

R_r , thermal resistance of the wall or roof structure, hr ft^2 °F/Btu

R_i , interior air resistance, hr ft^2 °F/Btu

The equation used to determine the air conditioning load is,

$$\frac{q_{cooling}}{A} = \frac{t - t_i}{(R_r + R_i)}$$

where

$q_{cooling}$, the heat that must be removed by the air conditioning in order to maintain a constant interior air temperature, Btu/hr

A, the roof or wall heat transfer area, ft^2

III. THE EXPERIMENTAL SYSTEM

A wall panel having an R value somewhat typical of a building wall, namely, R = 12 hr ft^2 °F/Btu, was instrumented with surface thermo-couples, as well as a large, thin calibrated heat flux transducer. The vertical test panel front surface faced a battery of sun lamps that provided the simulated solar irradiation. The heat flux transducer was located in the middle of the vertical panel. Heat absorbed on the front surface of the panel was lost 1) by conduction through the panel into the air behind it and 2) by infrared radiation and natural air convection from the front surface of the panel.

IV. THE TEST PROCEDURE

From the hot and cold panel surface temperatures, the front and back ambient air temperatures and the heat flow transducer heat flux measurements, the system R values were determined. One set of measurements was made for the Thermilate -applied paint and the other set for ordinary house paint.

From the two sets of data, one can obtain the energy savings and the additional thermal resistance that would have to be added to the panel with ordinary paint to get the reduced heat flux attained by the panel with Thermilate added paint.

V. TEST RESULTS

The test results for the insulation panel with its outer surface painted with Thermilate paint follow:

t_0 = 77.9 °F	$\frac{q_{cooling}}{A} = 3.57^{*}$ Btu/hr ft^2
t_i = 75.9 °F	G = 308 Btu/hr ft^2
t_b = 80.3 °F	α = 0.19 (previously measured)
t = 121.8 °F	R_r = 12.0 hr ft^2 °F/Btu
	$R_i \cong 1.0$ hr ft^2 °F/Btu

The test results for the insulation panel with its outer surface painted with ordinary (light green) latex house paint follow:

$t_0 = 76.7\ °F$ $\quad \frac{q}{A} = 5.24$ Btu/hr ft^2

$t_i = 75.8\ °F$ $\quad G = 310$ Btu/hr ft^2

$t_b = 80.9$ $\quad \alpha = 0.3$

$t = 141.8\ °F$ $\quad R_r = 12.0$ hr ft^2 °F/Btu

$R_i \cong 1.0$ hr ft^2 °F/Btu

On the basis of these two sets of data, the energy savings obtained when using the Thermilate paint instead of an ordinary paint is,

*When substituting t, t_i, R_r and R_i into Equation (2), one obtains

$$\frac{q_{cooling}}{A} = \frac{t - t_i}{R_r + R_i} = \frac{121.8 - 75.9}{12 + 1.0} = 3.53 \text{ Btu/hr ft}^2,$$ which is good agreement with the measured value of 3.57 Btu/hr ft^2

$$\frac{5.24 - 3.57}{5.24} \times 100 = 31.9\%$$

It is also pointed out that if one added an additional thermal resistance of $R_{add.} = 6.0$ hr ft^2 °F/Btu to the wall system having the ordinary house paint on its outer surface, the higher heat flux being conducted into the building, namely,

5.24 Btu/hr ft^2 would be reduced to the lower heat flux value of 3.57 Btu/hr ft^2 for the wall painted with Thermilate paint. This additional resistance calculation is performed by a trial and error calculation using Equation (1) (by iterating R_r, t and q/A).

VI. CONCLUDING COMMENTS

It is pointed out that the energy savings terms and add, values are not just functions of the solar reflectivities and IR emissivities, but also of the Rr and system temperature information. It is also to be noted that ordinary paints can have a range of solar reflectivities and IR emissivities, depending upon their chemical constituency.

VII. SYNOPSIS

The following table shows the effective “R” values for common wall types.
The use of Thermilate® can dramatically increase the effective “R”value of these common wall types by over 50%!

No.	System Description	Whole Wall R-Value with Thermilate (Rww)
1.	12-in two-core insulating units concrete 120lb/ft3, EPS inserts 1 7/8-in thick, grout fillings 24 in o.c.	**3.6**
2.	12-in two-core insulating units wood concrete 40lb/ft3, EPS inserts 1 7/8-in thick, grout fillings 24 in o.c.	**8.6**
3.	12-in cut-web insulating units concrete 120lb/ft3, EPS inserts 2 1/2 in thick, grout fillings 16 in o.c.	**4.1**
4.	12-in cut-web insulating units wood concrete 40lb/ft3, EPS inserts 2 1/2 in thick, grout fillings 16 in o.c.	**9.2**
5.	12-in multicore insulating units polystyrene beads concrete 30lb/ft3, EPS inserts in all cores	**14.7**
6.	EPS block forms poured in place with concrete, block walls 1 7/8 in thick	**15.7**
7.	2 x 4 wood stud wall 16 in o.c., R-11 batts, 1/2-in plywood exterior, 1/2-in gypsum board interior	**9.6**
8.	2 x 4 wood stud wall 24 in o.c., R-11 batts, 1/2-in plywood exterior, 1/2-in gypsum board interior	**9.9**
9.	2 x 6 wood stud wall 24 in o.c., R-19 batts, 1/2-in plywood exterior, 1/2-in gypsum board interior	**13.7**
10.	Larsen truss walls 2 x 4 wood stud wall 16 in o.c., R-11 batts + 8-in-thick Larsen trusses insulated by 8-in-thick batts, 1/2-in plywood exterior, 1/2-in gypsum board interior	**38.5**
11.	Stressed-skin panel wall, 6-in-thick foam core + 1/2-in oriented strand board (OSB) boards, 1/2-in plywood exterior, 1/2-in gypsum board interior	**21.6**
12.	4-in metal stud wall 24 in o.c., R-11 batts, 1/2-in plywood exterior + 1-in EPS sheathing + 1/2-in wood siding, 1/2-in gypsum board interior. NAHB Energy Conservation House Details.	**10.9**
13.	3 1/2-in metal stud wall 16 in o.c., R-11 batts, 1/2-in plywood exterior + 1/2-in wood siding, 1/2-in gypsum board interior	**6.1**
14.	3 1/2-in metal stud wall 16 in o.c., R-11 batts, 1/2-in plywood exterior + 1/2-in EPS sheathing + 1/2-in wood siding, 1/2-in gypsum board interior. AISI Manual details	**8.0**
15.	3 1/2-in metal stud wall 16 in o.c., R-11 batts, 1/2-in plywood exterior + 1-in EPS sheathing + 1/2-in wood siding, 1/2-in gypsum board interior. AISI Manual details	**9.5**
16.	3 1/2-in metal stud wall 24 in o.c., R-11 batts, 1/2-in plywood exterior + 1/2-in wood siding, 1/2-in gypsum board interior. AISI Manual details	**7.1**
17.	3 1/2-in metal stud wall 24 in o.c., R-11 batts, 1/2-in plywood exterior + 1/2-in EPS sheathing + 1/2-in wood siding, 1/2-in gypsum board interior. AISI Manual details	**8.9**
18.	3 1/2-in metal stud wall 24 in o.c., R-11 batts, 1/2-in plywood exterior + 1-in EPS sheathing + 1/2-in wood siding, 1/2-in gypsum board interior. AISI Manual details	**10.2**