Cold Climate Housing Research Center
CCHRC

Product Test

Nansulate® and Super Therm®

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August 11, 2009

Technical Report #2009-01

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Abstract

Novel means to reduce home heating costs in cold climate residential construction are continuously sought after, leading to the introduction of numerous products with varying degrees of effectiveness in achieving this goal. Two coating products, Nansulate® Home Protect Clear Coat and Super Therm®, were evaluated to determine whether they contribute insulating properties to the building envelope when applied as an interior coating. Each coating was tested to determine whether it fits the definition of a radiant barrier, changes the R-value of material it coats, or reduces heating demand within an insulated miniature structure. Both products were found to lack any significant effect in reducing heat transfer or heating demand.

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Disclaimer: The products were tested using the methodologies described in this report. CCHRC cautions that different results might be obtained using different test methodologies. CCHRC suggests caution in drawing inferences regarding the products beyond the circumstances described in this report.

Introduction

All the parts of a home that separate the outside environment from the interior living space are collectively part of the building envelope. In cold climates, the demands placed on the building envelope are extreme. Therefore it is critical that construction methods selected are effective and durable to ensure that the home is energy efficient and comfortable. There are many products on the market that propose to increase the energy efficiency of a building. Some products are proven to do just that, but others make unproven claims. This study was designed to evaluate the claims of two products with such unproven claims. Nansulate® Home Protect Clear Coat (Industrial Nanotech, Inc.) and Super Therm® (Superior Products International II, Inc.) were tested to evaluate their effectiveness in improving the energy efficiency of homes in a heating dominated climate by enhancing the insulating properties of the building envelope.

Test Objectives

The tests conducted by CCHRC were designed to evaluate the effectiveness of the products as insulation when applied as an interior coating by:

1. Comparing the energy required to heat three insulated test boxes treated with different coatings, and
2. Determining the thermal conductivity and emittance of the coatings using standard test methods.

Product Background

Super Therm® is described on the manufacturer's website as a "ceramic based, water-borne, insulating coating" that "reflects over 95% of the three radiation [ultraviolet, visible and infrared] sources from the sun". SPI II Inc further claims that Super Therm®, when applied correctly, "can provide energy savings of 20 – 70%", and compares the product to traditional insulation methods by stating it has an R-19 equivalency, "replacing the 6 to 8 inches of traditional insulation to block initial heat load". Based on this description, and that Super Therm® is an Energy Star qualified product for roof coatings, it seems that the primary intended purpose for Super Therm® is to reduce solar heat gain in climates with significant cooling requirements. However, the manufacturer's website further states that Super Therm® can be used on "interior and exterior walls to keep heat in during winter".

Nansulate® Home Protect Clear Coat is sold as a water-based coating for "exterior and interior surfaces to give added home insulation benefit". This insulative property is purportedly a result of "an extremely low thermal conductivity" inherent to the nanoparticles dispersed within the coating. The nanoparticles are further described as having a R-value of 8.5 hr ft^2 ºF/BTU per inch. The website of the local distributor in Fairbanks, Alaska states that the product can result in savings of "20% to 40% on home heating cost".

Method Overview

Heat flows from a hot to a cold area in three ways, depending on what it is flowing through. Convection is the transfer of heat by the movement of a fluid, such as a liquid or gas. One feels convective heat transfer abundantly in winter by the cold wind robbing our body's warmth. When heat moves through a solid, it is by conduction, and the rate of the conduction depends on the kind of solid. Some solids are designed to inhibit conduction, like "blue board" extruded polystyrene insulation (XPS), others, like copper, are highly conductive and allow heat to pass freely. Heat can also be emitted by an object through radiation which is in the form of electromagnetic waves, a familiar sensation felt by the warming experienced when near a fire or hot wood stove. The R-value of a material, the inverse of the thermal conductance (thermal conductivity divided by the thickness of the material), is a value that indicates how well that material resists heat flow.

A house envelop is designed to minimize the heat flow out of the house. A vapor retarder limits convection and thick insulation limits heat loss by conduction. Heat loss by radiation can be reduced by radiant barriers, usually a layer of foil facing a small air gap. Often the loss by radiation is not addressed in cold climate home construction, except for windows that include “low-e” coatings.

In order to test the products as completely as possible, three different test tracks were developed. The tests addressed heat loss by conduction and radiation directly, and convection indirectly. Each test track was designed to evaluate the products' claims with a different method.

1. The emittance of each coating was determined by Air-Ins, a materials testing lab in Montreal, Canada. They tested each coating using the ASTM C1371 standard test method. The emittance of the coating gives an indication of how well the coating inhibits the loss of heat by radiation. “Emittance” is also commonly referred to as “emissivity”.
2. The thermal conductivity of each coating was determined using a modified version of the ASTM C518 standard test method. The test was modified because it is not designed to determine the conductivity of very thin coatings.
3. The coatings were also tested in a comparative, realistic test situation. Three identical insulated boxes were constructed and two were coated with the test products. The three boxes were heated with electric heaters and the energy required to maintain a temperature of 70ºF over the test period was monitored. The amount of energy required was compared to a control box, which was painted only with a white latex paint.

Infrared Emittance Testing

Air-Ins was contracted to perform emittance testing on samples of the coatings. They used standard test method ASTM C1371 to determine the emittance of the coatings when applied on gypsum board samples. The emittance of a specimen gives a good indication of whether it will reduce infrared radiant heat loss from a building. Most building materials have an emittance of approximately 0.9 in the infrared range, which doesn't make them good inhibitors of radiant heat loss. A low emittance material has an emittance of 0.1 or less according to ASTM C1224.

Test method ASTM C1371 employs an emissometer to determine the emittance of a specimen. Two known emittance standards are placed on a heat sink and used calibrate the emissometer. Then one of the standards is replaced by the sample and the emissometer calculates the emittance of the sample based on comparison to the known standard.

Thermal Conductivity Testing

Test method ASTM C518-04 is a method to determine the thermal conductivity of a flat specimen at a steady state condition. The method employs a heat flow meter to determine the conductivity. The CCHRC Product Testing Lab has a Fox 314 heat flow meter made by LaserComp, Inc (figure 1). The Fox 314 has a cold plate (top) and a hot plate (bottom) between which a 12 inch by 12 inch specimen is placed. The plates are set to maintain specified temperatures and the power input to maintain those temperatures is monitored. The Fox 314 meter also determines the specimen thickness, allowing the calculation of the thermal resistance or R-value of the specimen.

For this test the temperatures specified by the Federal Trade Commission (FTC) for labeling and advertising home insulation (16 CFR 460.5) were used. The FTC specifies a mean temperature of 75°F. To achieve this, 55°F and 95°F were used for the cold and hot plates, respectively.

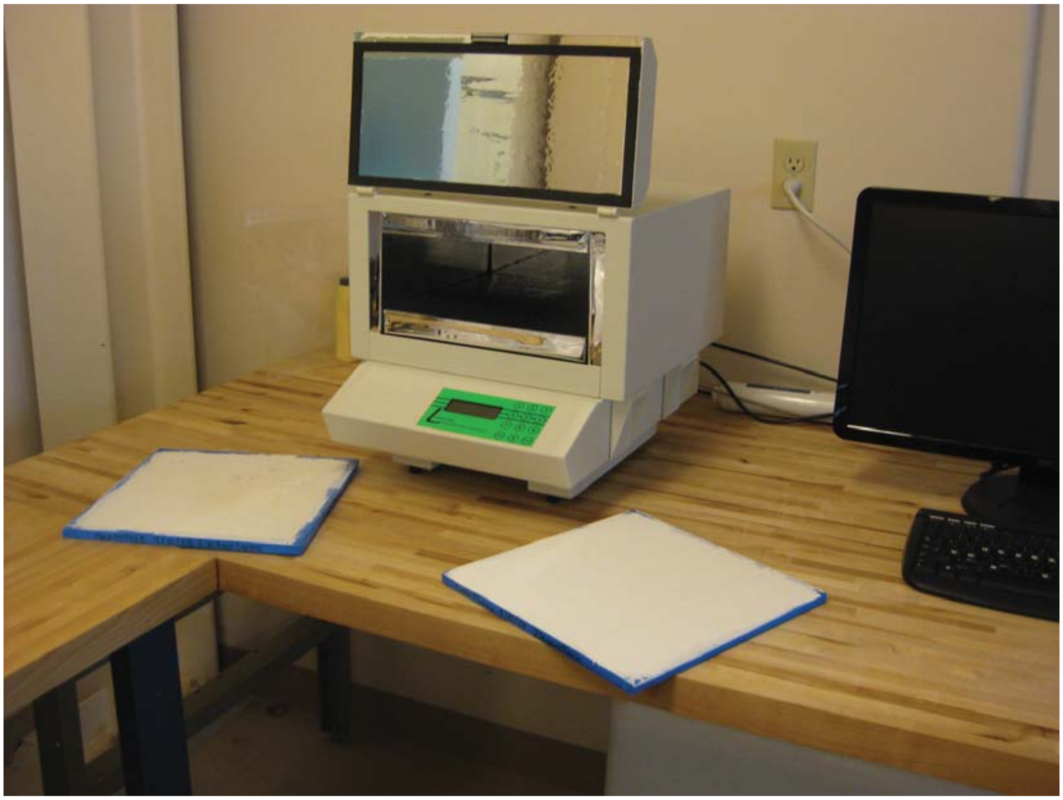

Figure 1. The Fox 314 with the two samples

In order to test the thermal conductivity of the coatings, the C518 test method had to be modified slightly. Two pieces of gypsum board were prepared for analysis in the Fox 314 prior to being painted. Each sample was 12 inches by 12 inches and ½ inch thick. Subsequently, the gypsum board samples were treated with the products as per the manufactures' directions (Nansulate® was applied in three 5 mil coats and Super Therm® was applied in two 16 mil coats). The samples cured for 30 days and then were tested for thermal conductivity in the Fox 314. Any difference in thermal conductivity from the pre-coating analysis was attributed to the coating.

Energy Monitoring Tests

The emittance and thermal conductivity testing were designed to establish relevant heat transfer properties of the coatings. To conduct a test that would directly demonstrate potential energy savings from the application of these coatings, insulated boxes were constructed to emulate typical home construction techniques on a practical scale.

Three identical boxes (figures 2 and 3) measuring approximately three feet on all sides were constructed with 2X4 studs and sheathed with ½-inch oriented strand board (OSB). The stud cavities were insulated with fiberglass batts, and the floor with four inches of XPS. A six millimeter polyethylene vapor retarder was placed over the fiberglass and sealed to the underlying XPS (see figure 2). Half-inch gypsum board was put on the inside, mudded and taped to a rough finish, and then painted with a flat white latex paint. The lid of the box was made of four inches of XPS attached to half-inch OSB on the outside and gypsum board on the inside. It fit into place with the lid gypsum board resting on the gypsum board of the box walls. It was compressed down onto the box with a tight elastic strap (see figure 3).

Figure 2. Picture of box construction before the gypsum board was added

Figure 3. Completed box set outside for testing

To ensure that the insulated boxes were equivalent in thermal performance, baseline tests were run prior to painting the interiors with the coating products. An Onset HOBO amp meter, a temperature sensor, and a datalogger were placed in each box. A small thermostatic controlled electric heater was also put in the box. The temperature sensor was placed 3 inches above the floor and slightly behind the heater (see figure 4).

Figure 4. Sensor Placement

The boxes were placed outside and the heaters operated overnight maintaining the inside temperature at an average of 74°F. Data were not collected during the day to avoid interference from solar heat gain. This control testing was conducted over the course of a week to ascertain that the boxes required the same amount of energy to maintain temperature. Table 1 shows a sample of the control testing data. Other baseline tests were run switching the heaters between the boxes to account for any variability the heaters introduced. The differences in energy consumed per box in the control tests fell within the error of the energy measurement (1.5%), so the boxes and heaters in this configuration were determined to be equivalent in energy use.

Table 1. Sample data from control testing

Date	Box	Heater	Datalogger	Energy (kWh)
3-19-2009	1	2	1	0.851
	2	3	2	0.846
	3	1	3	0.845

Once the thermal equivalency of the three boxes was established, the interior of box 1 was painted with Super Therm® and the interior of box 3 was painted with Nansulate®, both according to the manufactures' directions. The boxes were kept indoors or outdoors sealed with the heaters running to ensure a proper cure of the coatings. Following the painting, all three boxes were set up with the sensors and heaters just as they were in the control tests, and tested outside overnight once every two weeks for a 30 day period. Infrared (IR) photographs were taken in the mornings before the lids were removed to make certain each box had the same pattern of heat leakage. No anomalies were noted during the experiments. Figure 5 is an example of an IR picture taken of box 1 and part of box 2 on April 1.

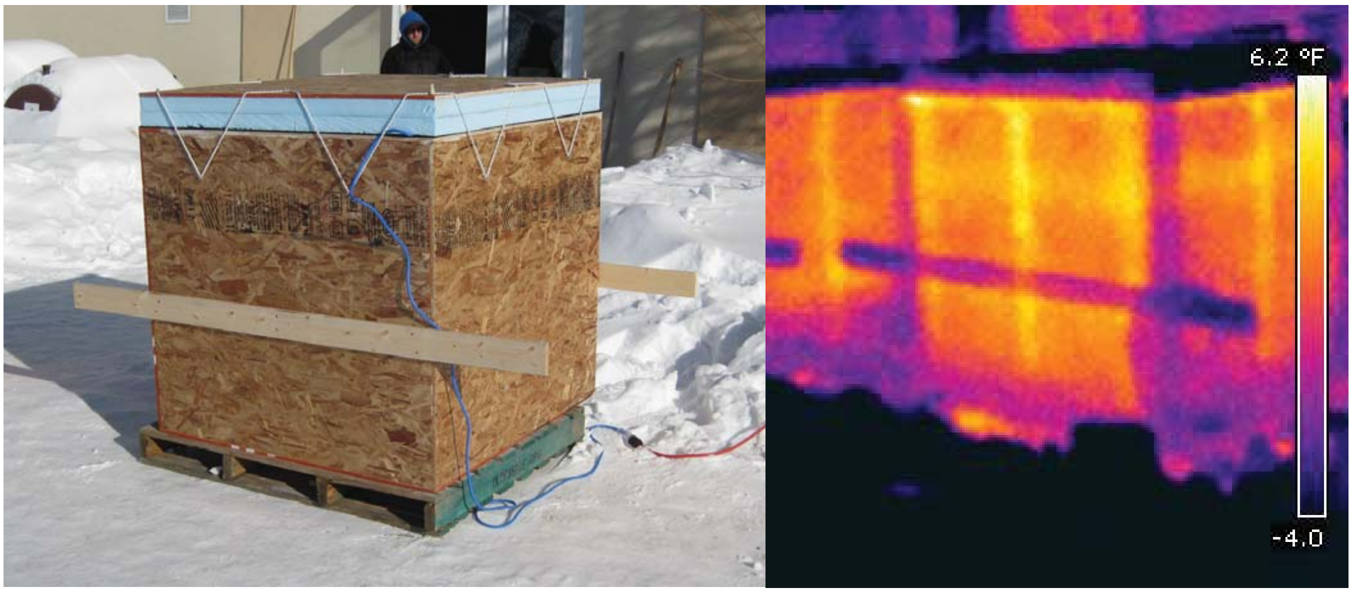

Figure 5. IR picture of box 1 (right) and roughly corresponding visible light photo (left).

Results and Discussion

Infrared Emittance Testing

Air-Ins tested the emittance of the coatings on three different samples for each coating. Super Therm® had an average emittance of 0.9 and Nansulate® had an average emittance of 0.92, which demonstrates that neither product is a good inhibitor of infrared radiant heat loss. While not quantified, the white latex paint used as a base coat in these tests is assumed to have an emittance of approximately 0.85 - 0.9 (ASHRAE, 2005). Compared with the aforementioned definition of a low emittance material (0.1 or less), the differences between these products is not significant.

Thermal Conductivity Testing

The thermal conductivity and R-values for the gypsum board samples are presented in Table 2. The samples were tested in two orientations, with the coatings facing up and with the coatings facing down. The Fox 314 heat flow meter determined the thermal conductivity (k) of the sample in BTU in/hr ft^2 °F and the sample thickness in inches. The R-value was calculated by dividing the sample thickness by the measured thermal conductivity.

Table 2. Conductivity testing for gypsum samples *Mean Temp of 75⁰F for all samples*				
Name/Orientation	Thickness (in)	Thermal Conductivity k (BTU in / hr ft^2 °F)	Change k with Coating	R-Value (hr ft^2 °F/BTU)
.05” Gypsum #1 Paper up	0.504	0.971		0.519
Nansulate® facing up, painted on gypsum	0.507	0.977	0.55%	0.519
0.5” Gypsum #1 paper down	0.504	0.970		0.520
Nansulate® facing down, painted on gypsum	0.507	0.976	0.64%	0.519
0.5” Gypsum #2 Paper up	0.504	0.973		0.518
Super Therm® facing up, painted on gypsum	0.520	1.00	3.0%	0.519
0.5” Gypsum #2 paper down	0.506	0.974		0.520
Super Therm® facing down, painted on gypsum	0.519	0.999	2.6%	0.519

Application of Super Therm® increased the thermal conductivity of the gypsum board and therefore decreased the overall R-value. Application of Nansulate® resulted in no significant difference, as the change in thermal conductivity for the Nansulate®-coated gypsum board is within the 1% measurement error of the Fox 314. While the increase in thermal conductivity by application of Super Therm® is larger than the error in the conductivity measurement, it does not cause a significant change in R-value. The insignificant change in the gypsum board R-value by both products demonstrates that the products do not contribute thermal resistance to the building envelope. To illustrate this point, Figure 6 compares of the effectiveness of these coatings on gypsum board when compared to common insulation materials.

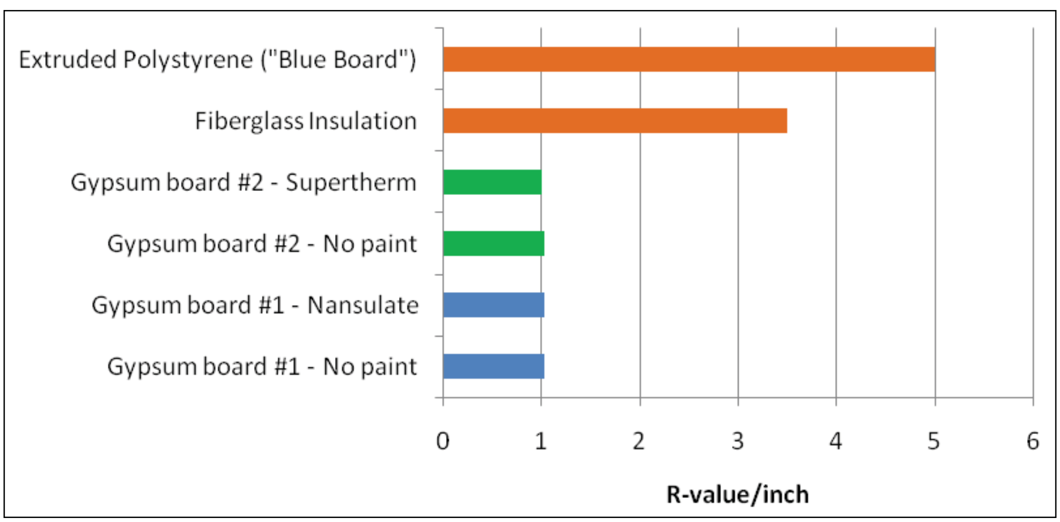

Figure 6. R-values per inch of the samples relative to common insulation materials

The ASTM test method C518 is designed to determine the thermal conductivity of a sample. Since heat conducts through a solid object the sample is in contact with the hot and cold plates and there are no air gaps to allow the reflection of radiant heat. We attempted to introduce an air gap into the Fox 314 to determine if the coatings had any effect on the minimal radiant heat transfer that exists on the warm lower plate, but the Fox 314 would not stabilize with the air gap. This idea was abandoned in favor of using the emittance tests described above to determine the effectiveness of the coatings in blocking infrared radiant heat loss.

Energy Monitoring Testing

There was no discernable difference in the performance of the Super Therm® or Nansulate® in comparison to regular latex paint during the energy monitoring tests (Table 3). Except for the test that ran the day after the boxes were painted, all three boxes performed approximately the same throughout the month. The poor performance on March 27 was probably due to the fact that the coatings were still drying. The application instructions for the coatings require that the coatings dry for 30 days at low humidity in order to attain a full cure. For this reason they were tested every other week over the span of thirty days with the last test occurring after thirty days of curing, on May 1.

Excluding the test on March 27, there was no dramatic difference in the performance of the two boxes with the coatings. This contradicts the claims by the manufactures that these coatings provide energy savings on the order of 20 to 70%, as quoted above. The differences in energy use between the three insulated boxes were generally greater after application of Nansulate® and Super Therm®, but these differences, after the initial test conducted on March 27, were not large, did not have a distinct pattern, and were not repeatable. The error in the energy measurement (1.5%) and minute variations between the three test boxes introduces experimental uncertainty of a similar magnitude. Therefore, the energy required to heat the three boxes is considered to be approximately equal within the limitations of the test method.

Table 3. Final Energy Usage for Heating the Boxes

Test Date	Testing Environment	Average Exterior Temperature	Energy Required to the Heat Test Box (kWh)				
			Box 2	Box 1		Box 3	
			Control	Super Therm	Change	Nansulate	Change
3/27/2009	Outside	20 F	0.326	0.460	40.9%	0.383	17.2%
4/1/2009	Outside	-2F	0.868	0.843	-2.9%	0.859	-1.0%
4/2/2009	Outside	10 F	1.261	1.261	0%	1.245	-1.3%
4/8/2009	Outside	20 F	0.566	0.591	4.4%	0.603	6.4%
5/1/2009	Environ. chamber	3 F	0.588	0.569	-3.2%	0.618	5.1%

Figure 7 illustrates the data from Table 3, showing the very small variation in the three boxes' energy use after the initial test.

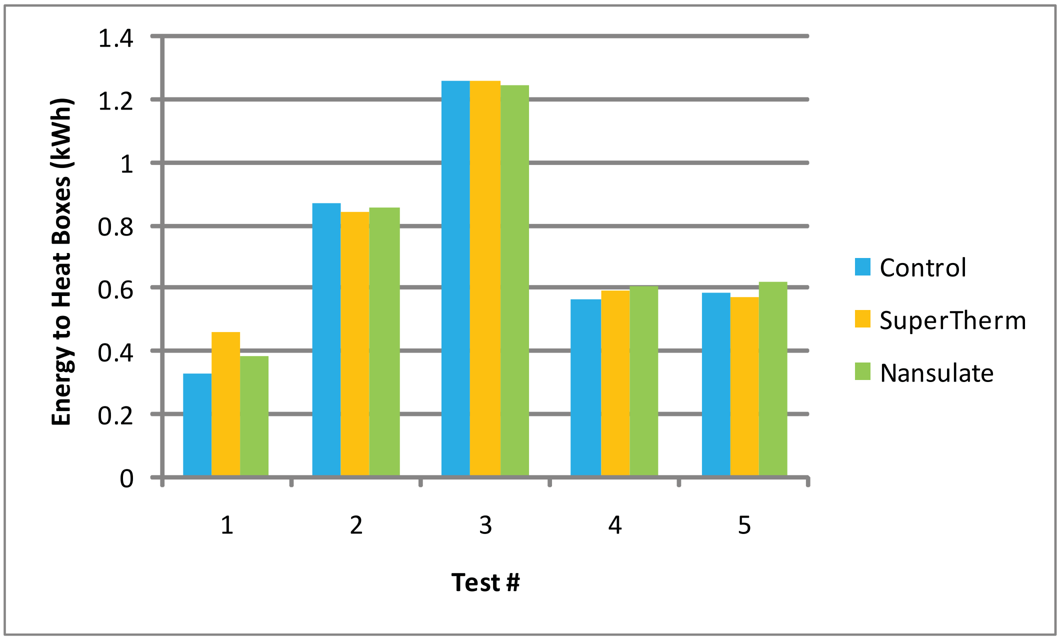

Figure 7. Similarities in Energy Performance

Conclusions

Having sufficient thermal insulation is particularly important in cold climates where heating can dominate home energy costs. There are known methods for improving the energy efficiency of home, such as adding additional insulation (such as fiberglass, polystyrene boards, and others), improving air tightness, upgrading windows, installing a more efficient heating system, and so forth. While each house presents unique factors to consider, these methods are well established and understood. The results from tests conducted by CCHRC show that the use of Super Therm® or Nansulate® to achieve extra energy efficiency in cold climates will not be effective. This statement is supported by three lines of evidence:

1. The coatings did not demonstrate an energy savings in the realistic box tests we conducted;

2. Neither product has an emittance that would make them effective in reducing heat loss by infrared radiation;

3. Neither product contributed to the R-value of the building material on which they were applied.

While these findings are conclusive for interior applications in heating-dominated climates, it is possible that there are other scenarios where these products could be effective in reducing energy costs for residential homes. As mentioned above, Super Therm® is an Energy Star qualified product for roof coatings. Such products have the primary goal of reducing solar absorption to decrease air conditioning loads. Such considerations were not included in our tests, as they are not considered of primary importance for Alaska's climate.

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Acknowledgements

The authors would like to thank the Alaska Housing Finance Corporation for the funding of this study, as well as several individuals that provided helpful assistance and feedback during the study: Robert Jutras and Gilbert Riopel (Air-Ins), Rich Seifert (UAF Cooperative Extension Service), John Zarling, Ph.D, P.E., and our colleagues at CCHRC.

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