SUPERIOR PRODUCTS
INTERNATIONAL II, INC.

HEAT INSULATION
USING EMISSIVITY/ REFLECTIVITY TESTING
Compared to Traditional Standard Methods

Conventional Insulation Materials:

Fiberglass/foam/cellulose/rockwool, etc.

R-Factor – Resistence to heat traveling through the insulation.

a. Conventional insulation does not exhibit any reflective heat performance. Radiant heat is absorbed by and travel through conventional insulation.
b. Conventional insulation (conductive heat barriers) allows heat to be absorbed by a substrate or surface and to travel (conduct) through and load into that substrate or surface.
c. R-Factor in conventional insulation is a measurement of the resistance of the insulation to heat traveling through the insulation. The thicker the insulation, the higher the R-Factor.
d. The heat conducting through conventional insulation is only slowed down by the resistance of the insulation and will eventually load into and enter the building. When the cool-down cycle starts (evenings and nights), the resistance of conventional insulation will also keep the heat from exiting from inside the building.
e. In a typical measurement of how batt type insulation may work, one will probe the top of the layer of the material and find that it is within a couple of degrees of the ambient temperature of the room. This measurement does not give any indication as to how well the material is working or not as this is a Craft paper backing that only absorbed the ambient and this is all this means. Next a typical measurement is taken on the batt material where it presses against the exterior wall. It is usually found that the interior surface of the exterior wall facing the batt material may be warm and this is thought to be good showing that the temperature is warm and holding heat in the room. This is not a good sign for the following reason: The material is a thick mass of fibers. It cannot block or reflect the heat gain that it will receive, therefore, it absorbs almost 100% of the heat. After it absorbs the heat, the R factor is used to record how much and how fast this "heat transfer" through the material happens. This would mean that the heat will pass through the material and heat up the inside surface of the exterior wall in the winter time. Is this good? No. Why? This shows that the heat that is passing through the material is loading into the surface of the wall. If heat is allowed to load into a surface or substrate, then it will continue to transfer and move to the cold side. This heat transfer is slow, but it is constant. As the mass of material loads heat, it then loads this same heat into the wall that is lost to the cold exterior. This type of material allows a 100% load as witnessed by the measurement of temperature on the interior surface of the batt material and then through "heat transfer" is lost to the cold side through the substrate.

Advanced Technology Insulation:

SUPER THERM®

Reflectivity and Infrared Emissivity – Barrier to radiant heat (either sunlight or mechanical heat sources).

Emissivity is viewed in two different ways: 1.)Absorption and 2.)Rate of Repelling heat off the surface.

a. Reflection of Heat:
   Low Absorption/Emissivity (0 is the best and 1.0 the worst)
   Absorption/emissivity is a measurement of the amount of heat that is absorbed into a surface and that is not reflected. Therefore, the more heat that is reflected, the less heat that is absorbed into a surface and the less heat that can load and travel through the substrate.
   SUPER THERM® has a .05 absorption/emittance ratio which means that it absorbs only a 5% of radiant heat regardless of sun radiation or mechanical heat since both are mainly Infrared as compared to 100% absorbed by conventional batt insulation materials.

b. Radiation of Absorbed Heat:
   Infrared Emissivity (1.00 is the best and 0 is the worst)
   Infrared emissivity is a measurement of how effectively absorbed heat is radiated away. It is the percentage of absorbed energy that can be released effectively. High "far infrared" emittance helps the surface release and discard heat by re-radiation.
   SUPER THERM® has a .95% or more infrared emissivity ratio which means that it is extremely efficient at releasing the small amount of energy/heat that it absorbs.

SUPER THERM® Results:

Reflection of Heat:

a. **With a combined reflection value of 95%, gives a heat absorption of 5% over a substrate in the short wave (visual) and long wave (infrared level) types of heat radiation.**
b. **The desire is for the highest reflectivity on each of the wavelengths. The more heat that is reflected or repelled from the surface, the less heat that can be absorbed and transferred.**
c. **Blocking Short Wave, Sunshine reflectivity = 92.2%**
   JIS A 5759 (Film for window) 5.3.4 (b) procedure
d. **Blocking Long Wave, Infrared reflectivity = 99.5%**
   JIS A 5759 (Film for window) 5.3.4 (c) procedure
a. **UV radiation is 100%** due to Tio2 blockage and white color.

Infrared Emissivity:

a. **Emissivity: 0.9**
   Tennessee Technological University, David Yarbrough.
b. **Rate of release/discard of heat from the surface of the substrate.**
c. **1.0 is the best and 0 is the worst on rate of infrared emissivity.**
d. **SUPER THERM® releases/discards the small amount of heat that it does absorb in an extremely efficient and fast manner.**

Summary:

SUPER THERM® tested with a very low <u>"absorption"</u> emissivity of 0.05 and a very high "<u>infrared emissivity</u>" in the different radiation wave lengths of 92% and 99% .

The combination of the <u>absorption</u> emissivity of 0.05 and the infrared emissivity of 0.90 to release the surface heat and reflectivity in the different wave lengths of 92% for visual light (short wave) and 99% for infrared (long wave) radiations makes SUPER THERM® an excellent coating to be applied over substrates to prevent heat gain into the surface while eliminating the heat from the surface very quickly.

This type of coating performance is what the Cool Roof committees across the US have written as their ideal performance criteria for such a roof coating.

California COOL ROOF Program engineering studies reported that heat gain is from the following:

a. **Ultraviolet (UV) – 3% of total, responsible for sunburn**
b. **Visible (VIS) – 40%, of total, visible light**
c. **Infrared (IR) – 57% of total, felt as heat.**

This being a given: <u>SUPER THERM® blocks the following:</u>

a. **Ultraviolet (UV) – 100%**
b. **Visible (VIS) – 92.2%**
c. **Infrared (IR) – 99.5%**

<u>Of the 97% of heat gain from radiation as given from the COOL ROOF study, SUPER THERM® blocks approximately. 95.9% in laboratory studies and 87% in field studies covering 26 million sq.ft. of roofing space through all seasons and conditions over a 12 year period.</u>

Conclusion:

Conventional forms of batt insulation absorb 100% loading of radiant heat. Then the batt insulation uses thickness to resist the migration of this heat load into the facility. The R-factor is a measurement of how much heat and how long it takes for this heat to "transfer/travel" through the insulation.

SUPER THERM® absorbs only 5% of the radiant heat and reflects/blocks 95% of the heat load from the surface of the substrate. With this reduced heat load, there is 95% less heat to "transfer/travel" through the substrate, as either gain or loss to the facility.

White paint can also have a good infrared emissivity for the cool roof programs, but it continues to load heat into the surface. White paint will reflect the surface heat at a high rate which can be equal to the heat load into the surface, such as a white car in the sun. There is an equilibrium heat load reached by a surface at which time, the heat is repelled at the same level of the surface heat load. The surface is hot, but it can repel the heat quickly when the sun goes down to allow the car surface to cool quicker than a black car surface. Point is, the surface did load with heat and transferred this heat during the radiation part of the day which makes the interior very hot.

The keys are to prevent the absorption/loading of heat into the surface and to repel the heat that is absorbed at a high rate during the loading process and not waiting until the sun goes down. In other words, during the hot part of the day, the surface of the SUPER THERM coated surface is not hot to the touch. SUPER THERM® performs both functions with an exceptional high degree of efficiency.

Question about Reflective Coatings and how do they match up:

If a coating is rated to be very good with reflectivity in light bounce or emissivity, does this mean it is as good as SUPER THERM in blocking heat load into the surface and preventing heat transfer? Absolutely not. White paint, even concrete, has a high emissivity reflective ratio with a white or light colored surface reflecting visual light. This is no indication that the coating can stop the loading of heat from short wave and long wave radiation as SUPER THERM does. If the surface of the coating or material with a high emissivity rating and good reflectivity is hot and allows the loading of heat into the surface like a white car hood, it is not performing the insulation effect desired. Heat is loading and transferring into the building. It is only reflecting the heat equilibrium reached after the surface loaded heat to it's capacity.

Additional comments:

1. Attached is a graph produced by the City of Burbank, Community Development Department, Building Division. The graph shows a black, grey and white surface and the resulting reflectivity and emissivity values. Clearly, the reflect factor is the most important point in preventing heat build up and absorption on the surface, while the emissivity (in this case, the rate at which the heat is repelled) is almost the same percentage on the black and white surface which is after the fact of heat load.- One page. SUPER THERM reflects 95% of the heat and has a emissivity of 0.9 (1.0 the best) to expel the infrared surface heat as it loads, not after it loads to equilibrium.

2. As an example of the misunderstanding of the use of emissivity and how this relates to heat blocking or repelling off the surface, a chart was produced by Sierra Pacific Infrared showing different products and their emittance values. There is no problem with the chart and values. The problem is that someone might think that if the emissive value is high as in this listing, this means it would be the best blockage of heat on a roof and therefore, no heat load. With concrete having a emissivity of .94, one could think this is fantastic and believe concrete is an excellent insulation. This simply means that in some concretes, after the sun goes down, the surface will throw off the heat very well and quickly. It is purely a rate of throwing off the surface heat. The concrete still loaded the maximum amount of heat it could during the sunlight hours which loaded and did a heat transfer through the wall or roof. – Two pages. SUPER THERM blocks the loading of heat by 95% whereas white materials will load 100% of it's absorptive heat such as a white car surface, concrete, etc. because they cannot effectively block IR radiation but have a high emissivity to unload the surface heat after the sun goes down. Problem is the materials loaded / absorbed the heat during the heated period of the day which transferred through the substrate.

3. Johns Manville produced charts that point to the fact that reflectivity is vital to keeping a roof cool, while the emissivity of the roof surface must be high to repel the infrared radiation that contributes to the heating of the surface. This is a factor during the day when infrared is the main heat radiation and at night to unload the surface heat from infrared. – Two pages. SUPER THERM tested for 99.5% of infrared radiation block and 92% of visual radiation block on reflection and 0.9 out of possible best scale of 1.0 emittance to release the surface heat during the day and night. In a message from PhD Inn Choi, Doctorate of Heat Transfer, talking about the charts and what they represent, his response is as follows: "Most houses that have insulating material (fiberglass, etc.) under the roof have to live with the reality that the heat absorbed by fiberglass in daytime must be emitted back into the outer space at night in order to improve home energy efficiency. If there were no heat source like fiberglass under the roof to begin with, nobody would talk about the need of high-emissivity roofing material. As far as people living under fiberglass clad homes, the emissivity will stay with us for a long time. The cool roof code in the attachment is an evidence of such a legacy. Curiously, while State codes include emissivity, Federal agency codes (EPA, DOE) don't." See the two pages attached showing State requirements and USA.

4. Emissivity definition from PhD Inn Choi, Heat Transfer Doctorate. – One page.

Cool Roof Properties

There are two properties that define a 'Cool Roof':

1. High ***REFLECTIVITY***- the ability of the roof coating to reflect away the sun's energy instead of absorbing it, and
2. High ***EMISSIVITY***- the ability of the roofing material to radiate away any energy they do absorb.

' Cool Roofs' Requirements

RESIDENTIAL

Prior to January 1, 2003, when roofing products must be certified and labeled in accordance with State requirements, manufacturer's published product performance data must show compliance with the following:

- A ***REFLECTANCE*** of o.70 or higher for all roofs, except tile,
- A ***REFLECTANCE*** of 0.40 or higher for tile,
- A minimum ***EMITTANCE*** of 0.75
- Liquid applied roofing products must be applied at a minimum dry mil thickness of 20 mils across the entire roof.

Qualifying roofing products must also comply with minimum ASTM testing standards.
(American Society for Testing and Materials www.astm.org)

When You Need a 'Cool Roof'

A 'Cool Roof' can be beneficial when a building:

- Is in a climate with hot, sunny weather,
- Uses significant cooling energy,
- Has a large roof area compared to the rest of the building surface area, or

Has roofing that tends to be prematurely damaged by UV rays.

'Cool Roof' Estimator

The Oak Ridge National Laboratories has developed a cost savings estimator for 'Cool' roofs. By entering basic information concerning local energy costs
The estimator can be accessed at www.ornl.gov/roofs+walls/facts/RadiationControl.htm and then selecting "Estimator".

Cool Roof Advantages

Re-Roofing:

By reducing surface temperatures, 'Cool Roof' coatings can extend the life of roofing materials by preventing the extremes of thermal expansion and contraction and protecting the roofing materials from the effects of UV rays.

Ultraviolet rays promote roof aging and chemical breakdown, while expansion and contraction lead to thermal fatigue. Together, the effects of heat build-up and solar energy on building materials contribute to roofing system breakdown and possible premature replacement or re-roofing.

The Environment:

The Building Code allows built-up roof coverings to be re-roofed only once. This means a flat roof with two layers of roofing must be stripped and a new roof applied when simple repairs are no longer cost effective. Because "Cool Roof" coatings are applied over existing, built-up roofing material and therefore extend its life, there can be an added benefit in the reduction of materials produced, used, and thrown away. Prolonging the life span of roofing materials is an obvious environmental advantage.

The Disadvantages of a 'Cool Roof'

Maintenance

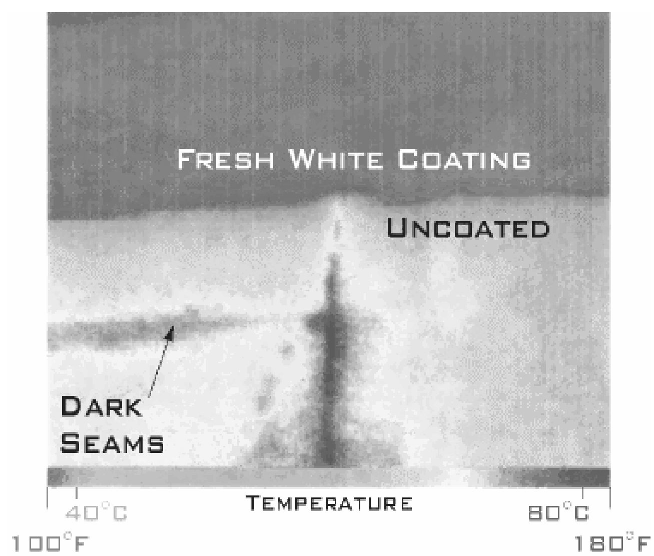
The success of a 'Cool Roof' relies on maintaining the reflectance of the roofing system. Energy savings are not necessarily constant over the lifetime of the system and as the solar reflectance changes, energy savings are also affected.

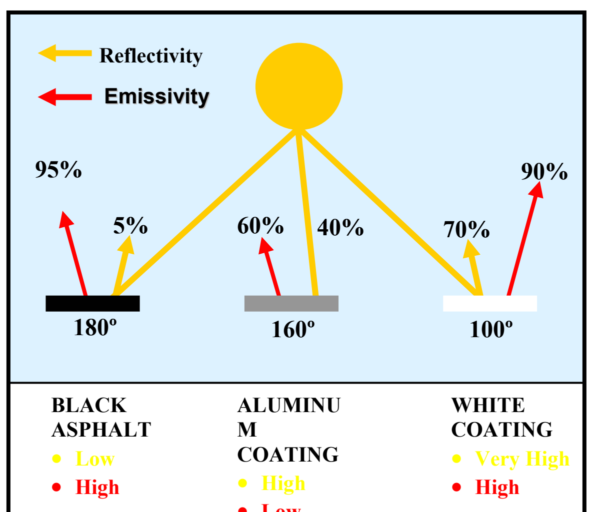
Color changes caused by aging, dirt pick-up through wind-blown dust, air borne pollutants, or water ponding, and the effects of biological attack can all reduce the reflectivity of the 'Cool Roof'. Continued maintenance and resurfacing, when necessary, are critical to roofing performance and continued energy savings

Winter Heating

'Cool Roofs' can decrease cooling costs by preventing heat build-up, but the same properties that reduce heat transfer during the summer months also reduce heat transfer during winter. This means that the installation of a 'Cool Roof' will generally increase heating costs. Because winter days are shorter and the sun angle is lower, there is less heat reflected and, therefore, less heat lost. This has been determined to be an acceptable trade-off, particularly where cooling costs are significant.

TEMPERATURE VARIATIONS IN ROOF COATINGS





Reflectivity, Emissivity & Roof Temperature

Published by the City of Burbank, **Community Development Department, Building Division**

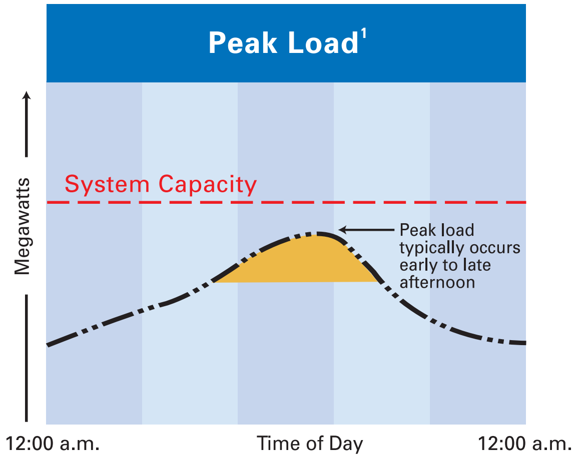
Emissivity table of some common materials. This is not a comprehensive list and should be taken as a guide only.		
Material	**Temp °C/°F**	**E**
Aluminum foil	27/81	0.04
Aluminum disc	27/81	0.18
Aluminum household (flat)	23/73	0.01
Aluminum (polished plate 98.3% pure)	227/440	0.04
	577/1070	0.06
Aluminum (rough plate)	26/78	0.06
Aluminum (oxidized @ 599°C)	199/390	0.11
	599/1110	0.19
Aluminum surfaced roofing	38/100	0.22
Aluminum colorized surfaces @ 599°C		
Copper	199/390	0.18
	599/1110	0.19
Steel	199/390	0.52
	599/1110	0.57
Asbestos board	23/74	0.96
Asbestos paper	38/100	0.93
	371/700	0.95
Asphalt (paving)	4/39	0.97
Brass (highly polished):		
73.2% Cu- 26.7% Zn	247/476	0.03
Brass (hard rolled - polished w/lines)	21/70	0.04
(some what attacked)	23/73	0.04
Brick (red - rough)	21/70	0.93
Brick (silica - unglazed rough)	1000/1832	0.80
Carbon (T - carbon 0.9% ash)	127/260	0.81
Concrete	-	0.94
Copper (polished)	21-117/70-242	0.02
Copper (scraped shiny not mirrored)	22/72	0.07
Copper (plate heavily oxidized)	25/77	0.78
Enamel (white fused on iron)	19/66	0.90
Formica	27/81	0.94
Frozen soil	-	0.93
Glass (smooth)	22/72	0.94
Gold (pure highly polished)	227/440	0.02
Granite (polished)	21/70	0.85
Ice	0/32	0.97

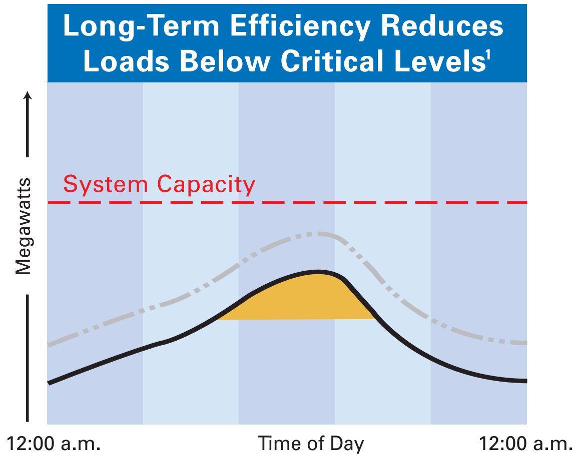
Emissivity table of some common materials. This is not a comprehensive list and should be taken as a guide only.		
Material	**Temp °C/°F**	**E**
Iron & Steel:		
Iron galvanized (bright)	-	0.13
Iron plate (completely rusted)	20/68	0.69
Rolled sheet steel	21/71	0.66
Oxidized iron	100/212	0.74
Wrought iron	21/70	0.94
Molten iron	1299-1399/3270-2550	0.29
Lead (pure 99.9% - unoxidized)	127/260	0.06
Marble (light gray polished)	22/72	0.93
Nickel wire	187/368	0.10
Paper (black tar)	-	0.93
Paper (white)	-	0.95
Plaster (white)	-	0.91
Plywood	19/66	0.96
Tin (bright tinned iron sheet)	25/77	0.04
Water	-	0.95
Wood (freshly planned)	-	0.90
Zinc galvanized sheet iron (bright)	28/82	0.23

Understanding "Cool" Roofs

Many factors affect the indoor temperature of a building and ultimately our comfort as building occupants. Environmental factors such as sunshine, clouds, humidity and wind speed all impact the building envelope causing a temperature change. The first line of defense for a building is the material selection and placement in the building envelope.

Highly infrared emissive and solar reflective roofing surfaces can help save money in air-conditioning costs because less heat is transferred into the building. Increased insulation can also mitigate this heat transfer. This translates into less cooling to keep people comfortable. This is especially true on hot afternoons in peak energy periods, such as 3 p.m. in the middle of July on a 90ºF day. Lower peak usage helps to reduce the chance of rolling power outages, which means businesses stay up and running.





1 Produced for the U.S. Department of Energy by the National Renewable Energy Laboratory, a DOE national laboratory, DOE/GO-102002-1613, September, 2001.

The Role of Reflectivity and Emissivity in Cool Roofs

In order to help better understand the concept of cool roofs, we need to understand reflectivity and emissivity.

Reflectivity

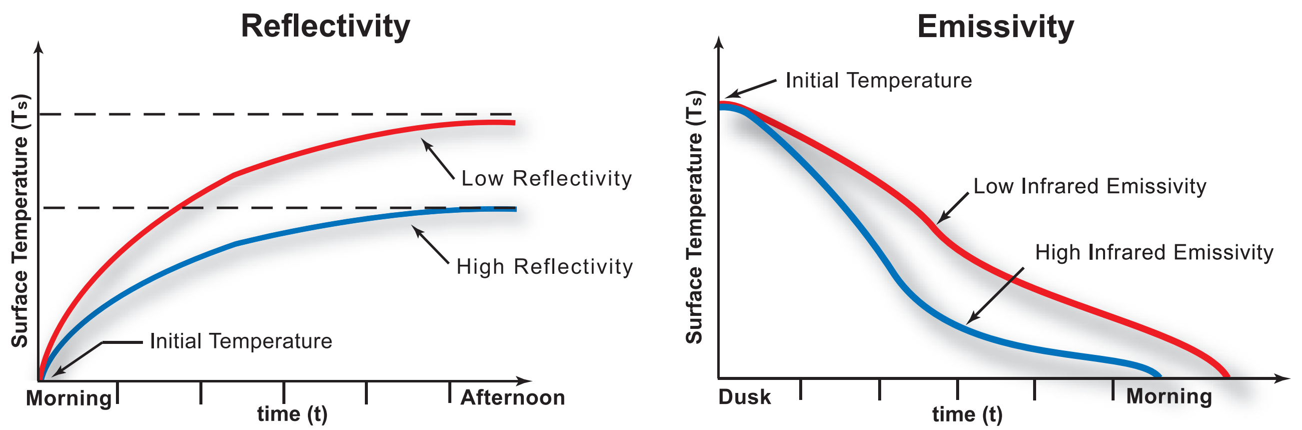
Solar reflectivity (or reflectance) is the fraction of the solar energy that is reflected by the surface (i.e., roofing membrane) back to the sky. White membranes have the highest solar reflectivity, while black have the lowest.

Emissivity

Infrared emissivity (or emittance) is a measure of the ability of a surface to shed some of its heat (in the form of infrared radiation) away from the surface (i.e., roofing membrane). High infrared emissivity helps keep surfaces cool. Metallic surfaces have a low infrared emissivity.

Conceptually, Figure 1 below demonstrates how the sun's solar radiation affects a product's reflective and emissive properties.

Figure 1. Illustrating Reflectivity and Emissivity



Conceptually, the above graph presents two products – one with high reflectivity, one with low reflectivity. During peak afternoon hours, the product with the higher reflectivity delivers a cooler roof top surface.

Conceptually, the above graph is presented to show that at dusk, when the sun's solar radiation diminishes, the higher emissive product dissipates stored heat at a faster rate than the lower emissive product.

Energy efficient material selection will impact indoor environmental comfort, which results in lower energy consumption and reduced demand during peak periods.

Figure 2 combines properties from three types of roofing products:

- White (cool) roof
- Aluminum-coated roof
- Dark roof

Highly reflective and highly emissive products, such as the white membrane, combined with the proper amount of roof insulation, offers a system that significantly reduces heat gain into the building.

Figure 2. Cool Roof Theory

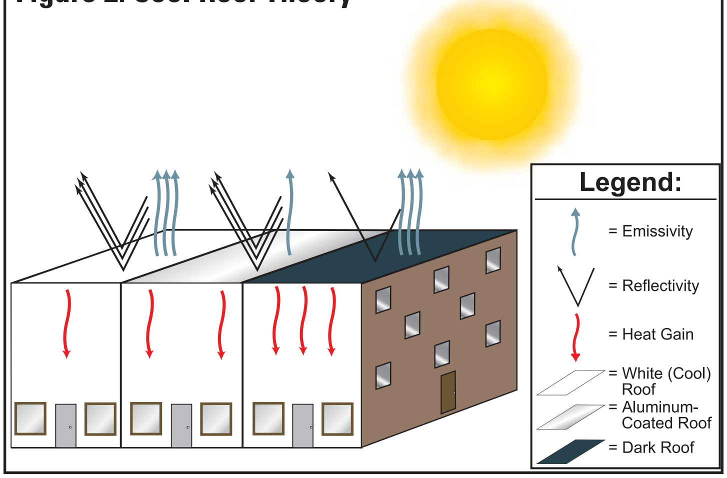


Figure 2 above is presented in a simplified form to illustrate the theory of "cool" roofs. There are many complex and related variables that must be considered when selecting the correct roofing product for the application.

Johns Manville

Roofing Systems Group
717 17th Street
Denver, CO 80202
1-800-654-3103
www.jm.com

RS-7616 4-05 (New)

EMISSIVITY

Description direct from Inn Choi, Ph.D.

When radiation energy falls on a body, the body will warm up until it emits as much heat as it absorbs and then stop warming, reaching a state of thermal equilibrium. If the heat loss by the body takes place in empty space, the only way in which the body can lose heat is through radiation. In that case its radiated energy flux will be equal to the absorbed flux. So

Reflectivity=1 - Absortivity. What this means is that if all energy is 'reflected', no energy is left to be 'absorbed'.

Absortivity = Emissivity. What this means is that only the 'absorbed' energy is emitted. So if there were no absorbtion of energy, there would be no emission of energy neither.

SuperTherm is reflective in visible as well as in infrared range. Again, if all energy were reflected, there would be no energy left to absorbed and emitted.

In reality, a surface can be hot from heat sources (such as heat from indoor) other than solar radiation. In this situation, having a high surface emittance will be beneficial if taking heat out of a surface is what is desired. But in summer time, we are more interested in blocking heat from coming into a building than allowing the heat come into a building and then trying to emit the heat out with a high emissivity surface material.

By the way, emissivity refers to the properties of a material; emittance to the properties of a particular object that depends on the shape of the object, oxidation and surface finish. As an example, if shiny metal surface which has a low emissivity is oxidated and gets dirty, its emissivity remains the same but its emittance becomes very high.

Cool Roof Codes and Programs

Cool Roof Rating Council (CRRC) Codes and Standards

Location	Agency	Policy Name	Description	Reflectance Requirement	Emissivity Requirement	Contact
Arizona	**Arizona Energy Commission**	**Tasked with developing an Energy Policy for AZ. Looking at adopting ASHRAE 90.1, 90.2.**	**Points structure. New construction only. Only applies to Energy Star-qualified contractors.**	**Energy Star**	**None**	**Ron Whipple, SWD Urethane Co. 480-969-8413 whip@swdurethane.com**
California	**California Energy Commission**	**Title 24**	**Performance credits for inclusion of cool roofs in buildings; CRRC named as supervisory entity**	**0.7**	**0.75**	**Virginia Lew 916-654-5106 title24@energy.state.ca.us**
Chicago, IL	**Department of Buildings**	**Energy Conservation Code (pdf)**	**Adoption of Energy Star as part of Energy Code, which is now part of the city's Building Code**	**0.25 before 12/31/08; Energy Star after**	**None**	**Gerry Bakker, Dept. of Environment 312-744-3634 en00237@cityofchicago.org**
Florida	**Department of Community Affairs**	**Florida Energy Code**	**Performance-based (need details)**	**0.65**	**0.8**	
Georgia	**Department of Community Affairs**	**Georgia Energy Code: Georgia White Roof Amendment**	**Requires use of additional insulation for roofing systems whose surfaces do not have test values of 0.75 or more for both solar reflectance and emissivity**	**0.75**	**0.75**	**Mike Lindsay 404-679-4845**
United	**ASHRAE**	**90.1**	**Absorptivity**	**0.7**	**0.75**	**Claire Ramspeck**

States		(Commercial Buildings) and 90.2 (Residential Buildings)	**Ratio. Considering proposal to include CRRC in cool roof component.**			**404-636-8400** cramspeck@ashrae.org

Voluntary Programs

Agency	Location	Program Name	Reflectance	Emissivity	Contact
Environmental Protection Agency/Department of Energy	**Federal**	Energy Star	**Low-slope: 0.65 (0.50 aged)Steep-slope: 0.25 (0.15 aged)**	**None**	**888-STAR-YES**
U.S. Green Building Council	**International**	LEED™ Green Building Rating System **for New Construction**	**Solar Reflectance Index (SRI) of 78 for low-slope and 29 for steep-sloped roofs.**		**202-828-7422** leedinfo@usgbc.org
Sacramento Tree Foundation	**Sacramento, CA**	Sacramento Cool Community Program			**Lisa Gartland, Director 510-595-PNRG** lisa@pstvnrg.com

TENNESSEE TECH

Tennessee Technological University
College of Engineering . *Department of Chemical Engineering*
Box 5013 . Cookeville, TN 38505 . 615-372-3297

January 23, 1989

Superior Products of Kan-Tex, Inc.
PO Box 2357
Salina, KS 67402-2357
Attn: Mr. Pritchard

Dear Mr. Pritchard,

I'm sorry you weren't able to attend the reflective coating meeting at Tenn Tech. Perhaps next time. Emittance measurements were made in December on the samples you prepared.

The results are as follows.

Material	Average Emittance (5 measurements)	Std. Deviation
1. Galvanized Metal	0.046	0.002
2. Therm Shield over Rust Shield over Metal	0.901	0.010
3. Therm Shield over gray layer, over rubber, or Rust Shield over metal	0.872	0.004
4. Round disk		
a) Water Shield Side	0.883	0.003
b) Thermo Shield Paint Side	0.874	0.011

The differences in emittance between 2,3,4a, and 4b are not significant. The high emittance (around 0.9) is a desirable property for exterior surfaces in the summer.

Sincerely,

David W. Yarbrough, Chairman
Department of Chemical Engineering

6-6, KOHJIMACHI, CHIYODA-KU, TOKYO 102 JAPAN
PHONE: (03) 3222-7651~61 FAX: (03) 3222-7691-5 TLX: 2466003 COSMIN J

5.

The test was done in accordance with JIS A 5759 (Film for Window) 5.3.4.(b)

(2) Long wave radiation ratio.

The test was done in accordance with JIS A 5759 (Film for Window) 5.3.4.(c)

2.3. Results of measure

Table 2 Results of measure

Item \ Specimen	1	2	3	Average
Sunshine Reflective Ratio	92.1	92.4	92.0	92.2
Long Wave Radiation Ratio	99.5			

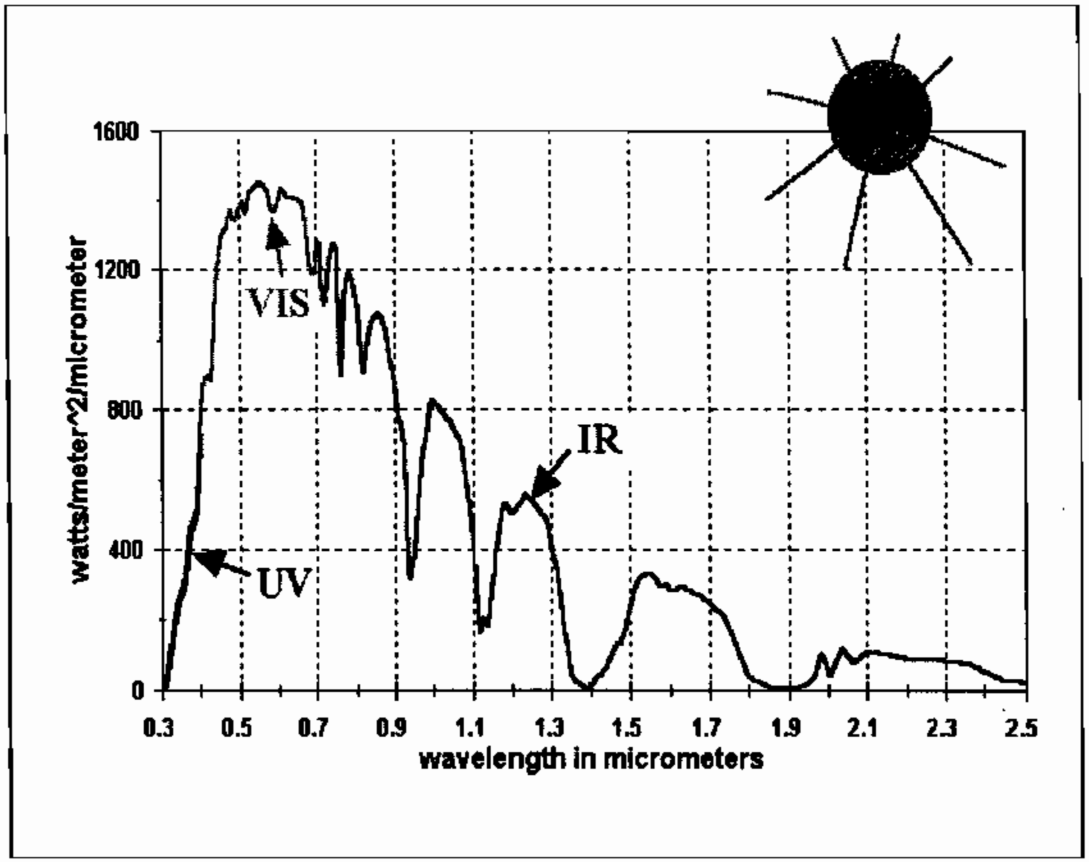
IR-

3.2. Results of calcuration

1) Tokyo

Simulation is showed on Chart 2 ~ 3.
The temparature of applied surface was lower than that of non-applied surface both slate roof and steel roof. But naturally there were not so difference at cloudy day (August 7). Therefore super Therm is effective as sunshine reflective material.
Table 3 shows the intruding calory from the roof by each term. This time calculate the intruding calory during air cooling and not calculate the amount of radiation to outside. That is to say, the amount of radiation is 0. Intruding calory shows the effect of Super Therm

Energy from the Sun



- Ultraviolet (UV)
  - 3% of total
  - responsible for sunburn
- Visible (VIS)
  - 40% of total
  - visible light
- Infrared (IR)
  - 57% of total
  - felt as heat

SUPERIOR PRODUCTS
INTERNATIONAL II INC
USA

BTU Conductivity Testing And Results.

TEST: ASTM E1269 differential scanning calorimeter and ASTM E1461-92, thermal diffusivity was measured using the laser flash technique.

"The thermal conductivity calculations of the metal plate are presented in Table 4 and the results are plotted in Figure 6. The calculations for the paint are given in Table 5 and shown in Figure 7. It should be noted that the conductivity of the paint is independent of the surface to which it is applied – that is, the conductivity of the paint is the same on a metal or a concrete surface."

1. TPRL testing lab: Stated in cm.2

Conductivity chart : (BTU /hr/ft2/F)

Temp	(W cm2 K)	BTU	
METAL PLATE			
73.4 F	0.50523	350.54	
122.0	0.52808	366.39	
176.0	0.52796	366.30	
212.0	0.52925	367.20	
SUPER THERM®			
73.4	0.00543	3.77	(one coat applied at 14 mils dry)
122.0	0.00564	3.92	"
176.0	0.00587	4.07	"
212.0	0.00575	3.99	"

(The common multiplier from the W cm2 K to BTU is 695 at cm -.00543X695=3.77 / .00564X695=3.92 / etc./etc.)

2. NETZSCH Instruments Inc. Stated in m 2

SUPER THERM®			
77.0	0.559	3.89	(one thin layer at 10-12-mils)

(The BTU was calculated from the same method as TPRL and using the common multiplier of 695. Exception is that this test was stated in meter and not cm, therefore the multiplier is 6.95).

The same test was performed by two different labs to verify our numbers and BTU conduction blocking ability. The results are within 5% and verified.

SUPERIOR PRODUCTS INTERNATIONAL II INC USA

CONCLUSION:

SUPER THERM® does effect conduction.
For conduction to be present, a substrate must load with heat whether radiation heat or other type. Once the substrate has loaded or absorbed the heat , the heat then transfers to the cool side of the substrate and this action is referred to as conduction or heat transfer which is the amount of time it takes for heat to absorb on one side, load and transfer to the other side.

When SUPER THERM® is applied to the substrate, two of the four ceramics used in the formula cannot absorb heat due to extreme low density. This prevents and / or significantly reduces the loading of heat on the heated side and therefore reduces or eliminates any heat transfer through the substrate. If there is no loading of heat and heat transfer, there is reduced or no conduction of heat.

SUPERIOR PRODUCTS
INTERNATIONAL II, INC.

INSULATION COATING
CORROSION PROTECTION

15 January 1997

Thermal Conductivity is the main point of insulation and this test is performed using the latest technology in Thermal testing equipment. The lab has explained in detail their procedures and results for better understanding. The Thermal Conduction Calculations are specific to the coating itself and not the combination of the surface it is painted over along with the coating. This gives the exact Thermal Conduction Calculation for the coating only, which is what is needed for this report.

To expedite the understanding of the report:

Table 4 is the Thermal Conductivity Calculation of the metal plate. It is established that the metal plate is only a standard measurement base material. The same calculations will be made on the SUPER THERM whether the painted surface is metal, concrete, stucco or any other material surface. Specific point of reference is at 212 degree F, 367.20 BTU is allowed to conduct through the base plate.

Table 5 is the Thermal conductivity Calculations of the thin film of the SUPER THERM only.
t=0.0149 is one single coat of SUPER THERM at 7 mils or 200 micron thickness.
t=0.0397 is two coats of SUPER THERM at 14 mils or 400 micron thickness.
t=0.0474 is three coats of SUPER THERM at 21 mils or 600 microns thickness.

Noted in **Table 5** is that the thin film of SUPER THERM is measured for its effectiveness as a thin film alone, without the benefit of the base material. The single coat of 7 mils or 200 microns thickness allowed only 3.99 BTU's to conduct compared to the metal plate that allowed 367.20 BTUs.

Another note is that it appears that a single coat of SUPER THERM can out-perform two coats and/or three coats. SUPER THERM was designed and its technology is built upon providing the insulation effectiveness on a single coat, with a minimum of 7 dry mils or 200 microns thickness. We have found in field useage that a second coat does add to the extra toughness and overall insulation ability. Two and three applications or coats are required if there is an intent on overcoating SUPER THERM with another paint product, which is usually a particular color over the top of the SUPER THERM for decoration. The extra thickness is required because the colored paint applied over the top of the SUPER THERM will catch and hold heat. Because of this fact, the extra layer of ceramics is required to effectively catch and throw the concentrated heat back into the surface coating and provide the best insulation effort.

We have also found that painting both sides of the base material or surface (metal, concrete or whatever material) improves the effectiveness of the insulation effort. We tried to measure this with the radiation test, but the ceramics on both sides caused such a distortion of the radiated beams that it could not be measured.

Regards,

J.E. Pritchett
President

10835 W. 78th Street • Shawnee, Kansas 66214 • Phone: 913-962-4848 Fax 913-962-6767

TABLE OF CONTENTS

List of Tables

List of Figures

Thermophysical Properties of SUPER THERM Coating

INTRODUCTION

A gallon of SUPER THERM coating and a metal plate were submitted for thermophysical property testing from room temperature to 100°C. Specific heat (C_p) was measured using a differential scanning calorimeter (ASTM E1269) and the thermal diffusivity (α) was measured using the laser flash technique (ASTM E1461-92). Several different thicknesses of coating were tested. The bulk density (d) was calculated from sample geometries and mass. The thermal conductivity (λ) was calculated as a product of these quantities, i.e. $\lambda = \alpha C_p d$.

The conductivity/diffusivity of one layer in a multi-layer composite is determined from the temperature rise curve of layered samples. The half rise time values are measured in the same fashion as that for single layer experiments. The half time value is corrected for heat losses using the Cowan Correction procedure. It is necessary to measure the thermal diffusivity of all but one layer and the specific heats of all layers in separate experiments prior to the calculations of the conductivity/diffusivity of the unknown layer. The diffusivity and conductivity of the unknown layer are calculated simultaneously from the temperature rise curve of layered samples using computer programs called TWOLA or THRLA. The input parameters for these programs include the thicknesses, densities and specific heats of all layers.

Thermal diffusivity is determined using the laser flash diffusivity method. In the flash method, the front face of a small disc-shaped sample is subjected to a short laser burst and the resulting rear face temperature rise is recorded and analyzed. A highly developed apparatus exists at TPRL (Figure 1) and we have been involved in an extensive program to evaluate the technique and broaden its uses. The apparatus consists of a Korad K2 laser, a high vacuum system including a bell jar with windows for viewing the sample, a tantalum or stainless steel tube heater surrounding a sample holding assembly, a thermocouple or an i.r. detector, appropriate biasing circuits, amplifiers, A/D converters, crystal clocks and a microcomputer based digital data acquisition system capable of accurately taking data in the 40 microsecond and longer time domain. The computer controls the experiment, collects the data, calculates the results and compares the raw data with the theoretical model.

Specific heat is measured using a standard Perkin-Elmer Model DSC-2 Differential Scanning Calorimeter (Figure 2) with sapphire as the reference material. The standard and sample were subjected to the same heat flux as a blank and the differential powers required to heat the sample and standard at the same rate were determined using the digital data acquisition system. From the masses of the sapphire standard and sample, the differential power, and the known specific heat of sapphire, the specific heat of the sample is computed. The experimental data are visually displayed as the experiment progresses. All measured quantities are directly traceable to NBS standards.

RESULTS AND DISCUSSION

Table 1 lists the diffusivity sample's dimensions, masses and bulk density values. The average density for the metal plate and the paint were used in the conductivity calculations.

The specific heat results for the plate and the paint are listed in Table 2 and are plotted in Figure 3.

The thermal diffusivity results for the plate are shown in Figure 4 and are included in Table 3 along with the results for the paint, which are plotted in Figure 5.

The thermal diffusivity of a material should not depend on its thickness except when the thickness is very thin. The differences that are present are most likely due to uncertainties in the thickness. Errors in the thickness are squared in the thermal diffusivity determinations, so that the ~10% difference in diffusivity at 100°C would translate into a 3.3% difference in the thickness, i.e. using a value of 0.0154 cm in place of 0.0149 cm for the thickness (a difference of only 0.0005 cm) would bring the diffusivity values into agreement.

The thermal conductivity calculations of the metal plate are presented in Table 4 and the results are plotted in Figure 6. The calculations for the paint are given in Table 5 and shown in Figure 7.

We attempted the three layer case with the coating on both sides of the plate, but did not get reasonable results. We applied a thin SiC layer to the front surface in case the laser beam was penetrating the SUPER THERM coating. Since adding a SiC layer turned the problem into four layers and the programs are limited to three layers, we had to assume that the SiC had no effect on the experiment or combine one of the paint layers with the metal plate to make it effectively one layer. With either assumption, we could not get reasonable results. We concluded the high sensitivity to the thicknesses of the thin layers was preventing the calculation of the diffusivity/conductivity. If the layers were thicker the results should have been the same as those determined by the two layer case.

The thermal resistance (R_{total}) of a layered material being equal to the sum of the thermal resistance of each layer when there is no contact resistance, that is: $R_{total} = R_1 + R_2 + \dots R_n$ with $R_n = P_n/\lambda_n$. P_n is the relative thickness of layer n, i.e $P_n = T_n/T_{total}$ and λ_n = thermal conductivity of layer n. So the thermal resistance of a material with any layer thicknesses can be calculated from the thicknesses and conductivities of the individual layers.

It should be noted that the conductivity of the paint is independent of the surface to which it is applied - that is, the conductivity of the paint is the same on a metal or a concrete surface.

TABLE 4

Thermal Conductivity Calculations

Sample (No.)	Temp. (C)	Density ($gm\ cm^{-3}$)	Specific Heat ($W\text{-}s\text{-}gm^{-1}K^{-1}$)	Diffusivity ($cm^2\ sec^{-1}$)	Conduct. ($W\text{-}cm^{-1}\ K^{-1}$)	Conduct. (BTU *)	Temp (F)
Plate	23.0	7.746	0.4407	0.14800	0.50523	350.54	73.4
	50.0	7.746	0.4638	0.14700	0.52808	366.39	122.0
	75.0	7.746	0.4800	0.14200	0.52796	366.30	167.0
	100.0	7.746	0.4951	0.13800	0.52925	367.20	212.0

* (BTU in $hr^{-1}\ ft^{-2}\ F^{-1}$)

Bare Metal Plate Without Super Therm®

TABLE 5

Thermal Conductivity Calculations

	Sample (No.)	Temp. (C)	Density ($gm\ cm^{-3}$)	Specific Heat ($W\text{-}s\text{-}gm^{-1}K^{-1}$)	Diffusivity ($cm^2\ sec^{-1}$)	Conduct. ($W\text{-}cm^{-1}\ K^{-1}$)	Conduct. (BTU *)	Temp (F)
One Coat of Super Therm® (7 Mils)	t=0.0149	23.0	1.639	1.1871	0.00279	0.00543	3.77	73.4
		50.0	1.639	1.2657	0.00272	0.00564	3.92	122.0
		75.0	1.639	1.3211	0.00271	0.00587	4.07	167.0
		100.0	1.639	1.3695	0.00256	0.00575	3.99	212.0
Two Coat of Super Therm® (14 Mils)	t=0.0397	23.0	1.639	1.1871	0.00324	0.00630	4.37	73.4
		50.0	1.639	1.2657	0.00303	0.00629	4.36	122.0
		75.0	1.639	1.3211	0.00287	0.00621	4.31	167.0
		100.0	1.639	1.3695	0.00274	0.00615	4.27	212.0
Three Coats of Super Therm® (21 Mils)	t=0.0474	23.0	1.639	1.1871	0.00324	0.00630	4.37	73.4
		50.0	1.639	1.2657	0.00311	0.00645	4.48	122.0
		75.0	1.639	1.3211	0.00300	0.00650	4.51	167.0
		100.0	1.639	1.3695	0.00285	0.00640	4.44	212.0

* (BTU in hr^{-1} ft^{-2} F^{-1})

Bare Metal Plate Coated on One Side with Super Therm®

Super Therm® Stopped 99% of Heat Conduction

NETZSCH

Page(s): 5

Date:	August 31, 2005	
To:	Neil Schultz	
	VTEC Laboratories	
Phone:	718-542-8248	
Fax:	718-542-8759	
From:	Rob Campbell (ext. 109)	r.campbell@nib.netzsch.us

Dear Neil,

Thermal conductivity results for the 4 materials you submitted for evaluation testing of the LFA 447 instrument follow. Please call if you have any questions.

Regards,

Robert Campbell
Applications Laboratory Manager
NETZSCH Instruments Inc.

25°C = 77°F

$$\frac{W}{m^\circ K} \times \frac{Btu}{W} \times \frac{M}{ft} \times \frac{K}{F}$$

Post-it® Fax Note 7671

Date 06/20/05		# of pages	5
To	JE / Tim	From	NEIL
Co./Dept.	Superior	Co.	VTEC
Phone #		Phone #	718-542-8248
Fax #	913-962-6767	Fax #	

ercaprel@spicoatings.com

##General_information	
#Database	vtech-078
#Instrument	#LFA_447
#Identity	242r0102 05.08.30
#Date	8/30/2005
#Material	supertherm
#Ref_temperature /°C	25
#Ref_density /(g/cm^3)	1.69
#Sample	**supertherm**
#Type	#Single_layer
#Thickness_RT/mm	0.506
#Diameter/mm	12.7
#Sensor	InSb
#Operator	rcc
#Remark_mment	Vtech
#Cp_table	supertherm
#Expansion_table	dL_const

##Results

Shot_number	Temperature/°C	Diffusivity/(mm^2/s)	Conductivity/(W/(m*K))	Cp/(J/g/K)
1	24.9	0.305	0.560	1.099
2	24.9	0.305	0.560	1.075
3	24.9	0.303	0.556	1.100
4	24.9	0.305	0.562	1.096
5	24.9	0.304	0.557	1.075
6	24.9	0.304	0.558	1.072
7	25.0	0.306	0.562	1.091
Mean	**24.9**	**0.304**	**0.559**	**1.087**
Std_Dev		0.0012	0.0022	0.0123

ASTM C-236 Testing for an "R" rating.
Post Test Review

SUPER THERM C-236 Full Report

We have learned that having an "R" rating means the material absorbs heat and is a measure of how long it can absorb and hold heat before it can migrate through it. The various ceramic compounds contained in SUPER THERM do not absorb heat but in fact repel heat in a manner similar to reflection.

In the effort to answer the question of how do we measure up to an "R" rated material as in fiberglass, we took on the ASTM C-236 ((C236-89(1993)e1 *Standard Test Method for Steady-State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box*)) testing for measuring R-values. The resistance from other engineering groups was that a known and accepted ASTM test had not been performed to compare the "R" values.

This test specifies a 3" fiberglass board be used as the control panel and tested. Then the board is tested with one coat of SUPER THERM applied to one side. Another board is tested with a coat on each side of the board.

The control board of the same 3" of fiberglass was tested and gave a .52** numerical value.

The board with one coat of SUPER THERM was tested and gave a .31** numerical value.

The board with two sides coated with the SUPER THERM gave a .21** numerical value.

** These are exact numbers for BTU heat conduction per sq. ft. / hour / F. The lower the number the better – to note the importance.

Our personnel discovered a note of importance when working with the labs to do the testing and comparison against the fiberglass. First, all fiberglass testing must be performed at 75 degrees F. Why, because this is the optimum temperature that the fiberglass can test and give the best results. When asked why this is the situation, it was stated that if the temperature drops below or rises above 75 degrees F, the fiberglass will suddenly drop in heat conductance value and therefore drop in it's R value very quickly. This seems very odd that an entire industry would accept such a material that only works best at one level of temperature and then base all the insulation requirements on a temperature level that is rarely achieved on any constant basis.

In speaking with some fiberglass people in France, their comment on whether or not the conductance value would drop at lower temperatures was answered as following: "The k value of an insulation does change with temperature, <u>but generally not much</u> at lower temperatures where radiation is not a major issue. <u>In general</u>, the lower the temperature, the better the k (lower value)....There would be a slightly poorer k value at 100 F".

VTEC labs in New York made the applications on the test panels. NATIONAL CERTIFIED TESTING LABORATORIES in Pennsylvania certified by ASTM did the ASTM testing. This testing was asked for by Bombardier in Mexico City for Train Cars to find a better material than fiberglass to use for insulation on their train cars.

The following comments were made by PhD Inn Choi that was on the research team with Owens Corning that developed the "R" rating and thickness requirements for fiberglass. His comments are concerning the C 236 test. The idea that thickness is linear as fiberglass suggest when testing three inches of fiberglass and then assuming the per inch R value will multiply out the same for each additional inch is false.

His comments: "The test was done to measure HTC (or conductance) indicating that there are two components (conduction and convection) that make up the thermal resistance (R-Value). For this test, it is not correct to interpolate R-value based on the test result of % heat loss reduction because a) convection is non-linear b) the 'change rate' of heat flux actually diminishes with increasing thickness. That is, heat loss reduction curve with respect to thickness change is hyperbolic, i.e. the initial big jump with small ST thickness will be followed by gradual tapering if we had increased ST thickness more.

There is another point. If we increase the thickness too much, the lab test like this becomes invalidated because the test (and most other lab test) is based on the assumption (and design) of one dimensional heat transfer. When the thickness becomes large, heat flows in two dimensions, thus creates a totally different ball game. In fact, this is another reason why we should be careful in extrapolating test results based on thickness."

As for SUPER THERM®, the performance of the reflectivity and the conductive abilities of the coating are not mislead by thickness. The coating is compact and forms a wall to block heat transfer and reflect surface heat. Thus eliminating the need for thickness as most all the heat is challenged immediately upon contact with the coating. The coating is not affected by moisture nor air convection.

Fiberglass is weakened substantially by moisture and air convection and is a certified health risk while SUPER THERM was approved by USDA labs as safe to use around foods.

As per PhD Inn Choi, thickness does not equal added effectiveness. He has stated in earlier materials that reflectivity of heat radiation (Infrared and other spectrum heat waves) are more important in blocking heat gain and load.

VTEC Laboratories Inc.

October 31, 2002

Mr. Francisco Morales Véliz
Bombardier Transportation
Domicilio Conocido, Zona Industrial
Cd. Sahagún, Edo. De Hgo C.P. 43990 México

RE: Comparison of completed ASTM C236 Tests

Dear Mr. Véliz,

Below is the summary of the results from the referenced job files. The percentages listed for the "Sample" fiberglass panels are compared to the "Control" panel; the "Plywood Laminate" and "Stainless Steel" panels did not have a "control" sample available for comparison. For specific test specimen data and test conditions please refer to the appropriate test report.

Report Number (NCTL-110-)	Test Specimen (24" x 48")	Thermal Conductance (Excluding Air Films)	R-Value (Per inch of thickness)	Percent Increase (from Control)
8373-01	Control – 3" Fiberglass with no coatings	0.52	1.92	-
8373-02	System 2 – 3" Fiberglass with 10 mil Super Therm coating on interior	0.31	3.23	68%
8373-05	System 4 – 3" Fiberglass with 50 mil Hot Therm and 10 mil Super Therm coating on interior	0.28	3.57	86%
8373-03	System 1 – 3" Fiberglass with 10 mil Super Therm coating on both sides	0.21	4.76	148%
8373-06	Plywood laminate with 50 mil Hot Therm and 10 mil Super Therm coating on interior	0.79	1.27	

If you have any questions, please contact me at your convenience.

Neil Schultz

212 Manida Street • Bronx, New York 10474 • (718) 542-8248 • Fax: (718) 542-8759 • www.vteclabs.com

VTEC Laboratories Inc.

January 28, 1998

Mr. J E. Pritchett
Superior Products International II, Inc
5459 Universal Ave
Kansas City, MO 64120
FAX 816-241-1772

Subject: Thermal Properties of Super Therm

Dear Mr Pritchett,

The ASTM C 177 was developed in the late 1930's to measure at that time the conventional ion thermal properties. The apparent thermal conductivity is what is measured because it cludes different heat transfer components such as conduction, radiation and convection (mass ansport)

The ASTM E1461-92 and the ASTM E 1269 test methods could be considered as an alternative method for determining the thermal properties of Super Therm.

As stated in the testing report performed at the Thermophysical Properties Research Laboratory, Inc., the calculated R- value is to be RE- 19.

Never hesitate to call.

Very truly yours,

Neil Schultz
Executive Director