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." Also and very important, on the conclusion page of the test report, the resulting W.cm K is multiplied by density to achieve the results - "The thermal conductivity was calculated as a product of these quantities times the "BULK DENSITY" (d), i.e. Conduction = aCpd." The results cannot be simply checked by on-line conversion charts.

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
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

(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.

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.

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

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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: $R_{total} = R_1 + R_2 + \ldots R_n$ 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.

#4

TABLE 4

Thermal Conductivity Calculations

Sample (No.)	Temp. (C)	Density ($gm\ cm^{-3}$)	Specific Heat ($W{-}s{-}gm^{-1}K^{-1}$)	Diffusivity ($cm^2\ sec^{-1}$)	Conduct. ($W{-}cm^{-1}\ K^{-1}$)	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 →

BARE METAL PLATE
WITHOUT SUPER THERM

TABLE 5

Thermal Conductivity Calculations

Sample (No.)	Temp. (C)	Density (gm cm^{-3})	Specific Heat (W-s-$gm^{-1}K^{-1}$)	Diffusivity (cm^2 sec^{-1})	Conduct. (W-cm^{-1} K^{-1})	Conduct. (BTU *)	Temp (F)
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
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
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})

One Coat 7 mils

Two Coats

Three Coats

Bare metal plate coated on one side with Super Therm.

Stopped 99% of heat conduction.

NETZSCH

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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

$\frac{W}{m^{\circ}K} \times \frac{Btu}{[illegible]} \times \frac{M}{[illegible]} \times \frac{K}{I}$

##General_information

#Database	vtech-078
#Instrument	#LFA_447
#Identity	242r0102 05.08 30
#Date	8/30/2005
#Material	supertherm
#Ref_temperature /°C	23
#Ref_density /(g/cm^3)	1.89
#Sample	**supertherm**
#Type	#Single_layer
#Thickness_RT/mm	0.506
#Diameter/mm	12.7
#Sensor	InSb
#Operator	rac
#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