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Thermal Performance of TEMP-COAT 101

Introduction

TEMP-COAT 101 is a liquid ceramic insulation capable of insulating surfaces between the range of -80℉(-61℃) to +350℉(177℃) with a guarantee t hat it will insulate and adhere to the surface it insulates. The thickness of the material is the control factor as to what temperatures the product can control.

TEMP-COAT 101 is approved by over 100 of the Fortune 500 manufacturers and many of their suppliers in the US. TEMP-COAT has carried approval from the US Navy, US Coast Guard and Lloyd's Register going back as far as 1996.

The largest market for TEMP-COAT for the past 10 years has centered around the CUI(Corrosion Under Insulation)issue. Industries ranging from Oil and Gas to the Maritime industries have embraced TEMP-COAT as a product that can stop corrosion, save energy, reduce labor costs, protect personnel, reduce inspection time and finally extend the life of their assets. Our product has performed well in heavy industrial and difficult environments for over 18 years. Our client list includes Shell Oil, Dow, DuPont, Union Carbide and Conoco to name a few. We also serve many of the large military manufacturers such as General Dynamics, Boeing, and Northrop Grumman.

TEMP-COAT is the oldest name in liquid ceramic coatings. We offer a 10 year warranty on all of our products and are here to assist with all aspects of your projects.

Thermal Testing

TEMP-COAT Brand Products has been actively involved in working towards accurate testing and modeling of the performance of TEMP-COAT 101. Standard test methods currently utilized by the insulation industry such as the C-177 fall short of evaluating the performance of thin films or any products below 1” in thickness. These thin films include insulation coatings, radiant barriers, foils and products of similar thickness.

Chevron has performed independent testing thru Hardgrove Engineers which is discussed in the attached document as well as below in this report.

TEMP-COAT Brand Products is currently a member of NACE and participating in NACE TEG 424X which is currently evaluating potential test methods for insulation coatings.

C-177 Results

Keeping in mind the lack of accuracy obtained by the C-177 test, below is are the results of a C-177 test run by TPRL laboratories. We feel these thermal conductivity values derived are not accurate due to the thickness of the sample evaluated. When using these values in thermal calculations or programs, there are significant differences in surface temperatures calculated vs. surface temperatures measured in the field.

With that said, even utilizing the values given in a standard C-177 are quite impressive and should not be dismissed. Our products are insulation coatings and should be considered as such.

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)
COAT	23.0	0.432	1.0760	0.00151	0.00076	0.49	73.4
	50.0	0.432	1.1400	0.00151	0.00074	0.52	122.0
	100.0	0.432	1.2370	0.00150	0.00080	0.55	212.0
	150.0	0.432	1.3160	0.00150	0.00085	0.59	302.0
	200.0	0.432	1.4020	0.00149	0.00090	0.63	392.0
	250.0	0.432	1.5060	0.00150	0.00097	0.68	482.0
Blanket	23.0	0.114	1.0870	0.00544	0.00067	0.47	73.4
	50.0	0.114	1.1990	0.00554	0.00076	0.53	122.0
	75.0	0.114	1.2965	0.00563	0.00083	0.58	167.0
	100.0	0.114	1.3820	0.00572	0.00090	0.63	212.0
	125.0	0.114	1.4525	0.00561	0.00096	0.67	257.0
	150.0	0.114	1.5050	0.00590	0.00101	0.70	302.0
	175.0	0.114	1.5550	0.00599	0.00106	0.74	347.0
	200.0	0.114	1.5870	0.00608	0.00110	0.76	392.0

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

Hardgrove Egineers Results

From the Hardgrove Engineers report on TEMP-COAT 101, The U value was determined to be 1.38 Btu. / hr. ^{o}F .ft$^{2.}$ This can be utilized to determine the $K_{effective}$, which is shown below.(Taken from the attachment)

"With reference to above comments, Yes U= k/l however, this k is not the standard thermal conductivity it is referred to in industry as effective thermal conductivity, $k_{effective}$. Therefore although k (which is an intrinsic property of any given material, in thermodynamic terms) is independent of thickness of insulation, $k_{effective}$ is not an intrinsic property of any given material and is a function of the thickness of insulation.

$K_{effective}$ = (U)(l) where l is the thickness in ft, and has the unit (Btu/hr. ^{o}F .ft^2)(ft) when U is expressed as (Btu/hr. ^{o}F .ft^2)= (U)(l)(12) when l is expressed in inch and the unit for $K_{effective}$ will be (Btu.inch/ hr. ^{o}F .ft^2)

Therefore, in this particularly case of Temp Coat of 168 mil thickness, the $k_{effective}$ is (1.38)(0.168)/12 (Btu.ft/hr. ^{o}F .ft^2) Ξ (0.01932)(12) Btu.inch/ hr. ^{o}F .ft^2 Ξ **0.232 Btu.inch/ hr. ^{o}F .ft^2**

3E

Many industry professionals rely across the globe rely on the 3E program available thru the NAIMA to evaluate their systems. Below are several runs of the 3E program with the given C-177 values for TEMP-COAT, Hardgrove Engineeers K value and traditional mineral fiber. The values are run at a process temperature of 300℉ as this i s the average temperature we see in industry across the board. TEMP-COAT 101 thickness used in the calculations will be 130 mils which is our recommended thickness at 300℉.

450 MF Blanket with All Service Jacketing

Personnel Protection Report

Item Description:
System Units: **ASTM C585**
Geometry Description: **Steel Duct/Tank - Flat Top**
Bare Surface Emittance: **0.8** Nominal Pipe Size:
Process Temp: **300 °F** Ave. Ambient Temp: **75 °F** Ave. Wind Speed: **0 mph**
Relative Humidity: **N/A** Dew Point: **N/A**
Personnel Protection Thickness: **1.0**
Outer Jacket Material: **All Service Jacket** Outer Surface Emittance: **0.9**
Insulation Layer 1: **450F MF BLANKET, Type II, C553-02** Thickness: **Varied**

Append To Audit | Browse...

Variable Insulation Thickness	Surface Temp (°F)	Heat Loss (BTU/hr/ft^2)	Efficiency (%)
Bare	299.6	657.70	
0.5	143.6	148.70	77.39
1.0	117.8	83.62	87.29
1.5	106.7	58.28	91.14
2.0	100.3	44.77	93.19
2.5	96.2	36.26	94.47

130 mils of TEMP-COAT 101 Utilizing C-177 K values

Personnel Protection Report

Item Description:
System Units: **ASTM C585**
Geometry Description: **Steel Duct/Tank - Flat Top**
Bare Surface Emittance: **0.8** Nominal Pipe Size:
Process Temp: **300 °F** Ave. Ambient Temp: **75 °F** Ave. Wind Speed: **0 mph**
Relative Humidity: **N/A** Dew Point: **N/A**
Condensation Control Thickness: **N/A**
Outer Jacket Material: **None** Outer Surface Emittance: **0**
Insulation Layer 1: **TEMP-COAT TPRL 0.56-0.63** Thickness: **0.13 in.**

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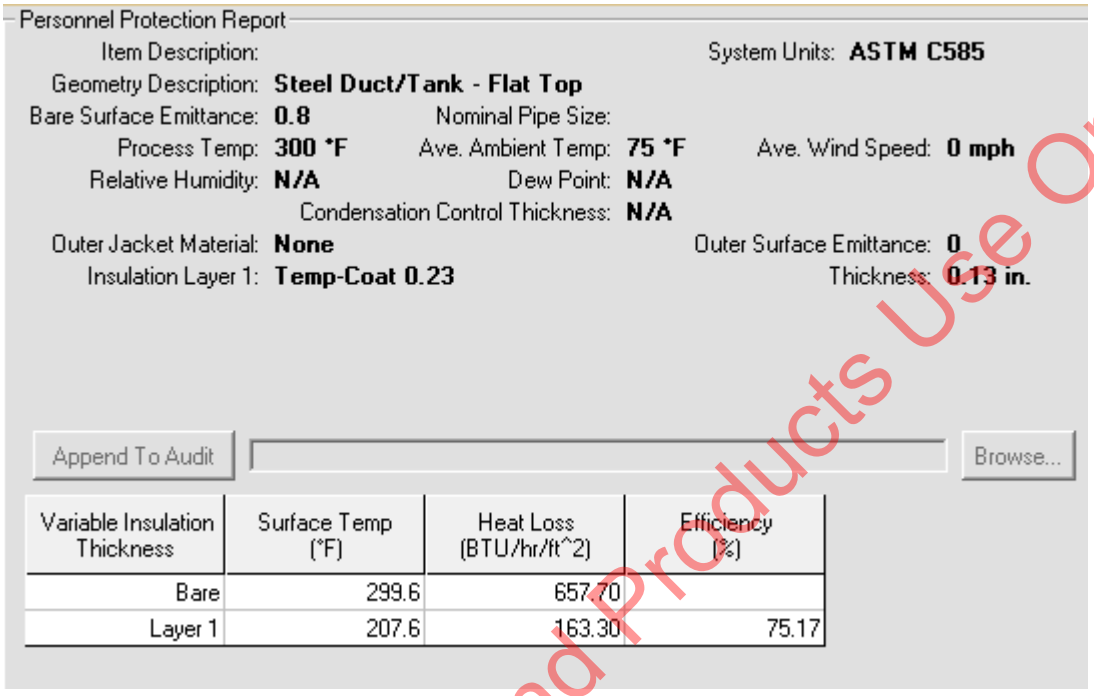
Variable Insulation Thickness	Surface Temp (°F)	Heat Loss (BTU/hr/ft^2)	Efficiency (%)
Bare	299.6	657.70	
Layer 1	248.8	229.20	65.15

130 mils of TEMP-COAT 101 Utilizing Hardgrove Engineers K effective 0.232



Personnel Protection Report

Item Description: System Units: **ASTM C585**
Geometry Description: **Steel Duct/Tank - Flat Top**
Bare Surface Emittance: **0.8** Nominal Pipe Size:
Process Temp: **300 °F** Ave. Ambient Temp: **75 °F** Ave. Wind Speed: **0 mph**
Relative Humidity: **N/A** Dew Point: **N/A**
Condensation Control Thickness: **N/A**
Outer Jacket Material: **None** Outer Surface Emittance: **0**
Insulation Layer 1: **Temp-Coat 0.23** Thickness: **0.13 in.**

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Variable Insulation Thickness	Surface Temp (°F)	Heat Loss (BTU/hr/ft^2)	Efficiency (%)
Bare	299.6	657.70	
Layer 1	207.6	163.30	75.17

Conclusion

Thermal Heat Loss & Efficiency

Summary of 3E Heat Loss Calculations for 300℉ Proc ess Temperature

Surface	Surface Temperature	Heat Loss (BTU/hr·ft²)	Efficiency (%)
Bare Steel	299.6	657.70	0
130 mils TEMP-COAT 101 @ C-177 K of 0.56 to 0.63 BTU·in/ hr·℉·ft²	248.6	228.7	65.22
130 mils TEMP-COAT 101 @ Keffective of 0.232 BTU·in/ hr·℉·ft²	207.6	163.3	75.17
0.5” Mineral Fiber	143.6	148.7	77.39
2” Mineral Fiber	100.7	44.7	93.77

Though TEMP-COAT does not perform one to one against 2” of industrial fiberglass lagging with the theoretical calculations provided by the 3E program, the Heat Loss and Efficiency performance of the thin film protective insulation system is quite impressive at 65.22% utilizing the C-177 test results. TEMP-COAT is a seamless barrier that protects the substrate from the infiltration of water while

providing insulation and personnel protection qualities. There are several factors to consider when evaluating a thermal coating vs traditional lagging.

THEORECTICAL VS. ACTUAL

Compression and Voids

There is very little information available on the effects of compression of fiberglass though there are several studies which indicate a 30% reduction of performance based on a compression of 1" which translates to a 7.5% reduction based on a compression of ¼". Assuming a ¼" compression by the installer is not un-reasonable with the attachment of stick pins on large objects such as tanks and the installation of jacketing.

Traditional Insulations are also subject to voids created by terminations and adjoining sections of materials. These losses are not accounted for in the basic calculations by most programs and engineers.

TEMP-COAT is installed as a seamless barrier. The ceramics used to create the air space withstand compression and the issue of voids is alleviated.

Humidity and Moisture

Traditional mass insulations are notorious for adding to the CUI issues plaguing industrial facilities world wide. There is very little information available on the effects of humidity on traditional systems. Most materials on the market will not necessarily absorb moisture. With that being said, the moisture content in the air between the cells of that material will directly affect the materials ability to perform.

Water infiltration in traditional covering systems due to poor installation, wind and storm damage, and common everyday occurrences of personnel walking or damaging the covering system can render mass systems saturated with water completely in-effective proving little to zero insulating capability.

These factors are generally not considered when evaluating the performances given by the C-177 testing and 3E evaluations.

Given the issues traditional mass insulations may have with compression, voids, humidity and moisture, the TEMP-COAT 101 systems overall performance is much closer to those traditional systems than what can be concluded at first glance. In many cases, TEMP-COAT'S "Actual Performance" can be much more effective that traditional systems.

Surface Temperature and Personnel Protection

Here is where the topic of thermal conductivity, C-177 testing and the 3E program begin to clash. Based on the 3E runs utilizing the thermal conductivity given by the C-177, the surface temperature given is 248.6℉. This is substantially higher than what can be expected with the use of 130 mils of TEMP-COAT 101. A 300℉ substrate temperature with 130 mils of TEMP-COAT 101 will have a surface temperature between 135℉ and 140℉. This skin temperature will also far exceed requirements outlined by OSHA as set by ASTM C1055 and C1057 referring to the 5 second temperature exposure to temperature at 140℉.

Engineers cannot utilize 3E when evaluating surface temperatures of TEMP-COAT as it will not give and accurate view of the performance of the product.

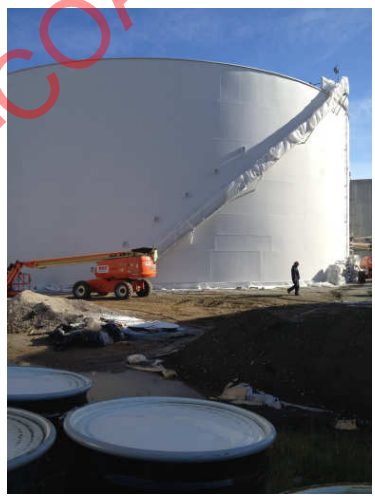
Advantages of TEMP-COAT Thermal Insulation Coating

Ease of Application

- Unlike the difficulty and time necessary to wrap and cover conventional systems. TEMP-COAT may be applied via traditional airless spray systems or for smaller tight area via our Quik Gun. Complex Geometries can be difficult to wrap but easy to coat. Systems traditionally not insulated due to the complex nature can be addressed

Seamless Barrier & CUI Protection

- TEMP-COAT provides a seamless barrier without the need for traditional covering systems that are easily damaged and difficult to repair.



Personnel Protection

- Unlike traditional standoff methods or aluminum mesh systems, TEMP-COAT not only provides burn protection. Difficult areas such as flanges and valves may be coated eliminating the need for expensive blankets that fail. TEMP-COAT 101 also provides energy savings, CUI protection and ultimately asset protecting.

Uninsulated – primed pipework- 130℃ (266℉)

TEMP-COAT®101 insulation reduced temperature to 65℃ (149℉)