INSULATION FACTS #81

NAIMA
North American Insulation Manufacturers Association

Insulation Products for Commercial and Industrial Applications:

Thermal Performance of Coatings Used to Insulate Pipes, Ducts, and Equipment

This fact sheet analyzes and discusses performance claims and recommendations by manufacturers of coatings (sometimes called ceramic coatings) used to insulate piping and equipment in mechanical applications.

Introduction

Over the past several years, manufacturers of insulating coatings have widely promoted the high R-values that their products provide. When used to insulate pipes, ducts and equipment, thermal resistances or R-values of R-19 or R-20 have been touted to owners of buildings and industrial facilities. These kinds of performance claims may seem attractive, especially when manufacturers say that a single coat of their product can provide such high thermal insulation values. However, a closer look at these coatings will confirm the old adage "If it sounds too good to be true, it probably is." The purpose of this fact sheet is to analyze in a technically credible manner the real thermal insulating performance of these coatings.

Thermal Performance Considerations

Thermal energy (heat) flows by one of three ways, those being conduction, convection or radiation. Conduction is the transfer of heat due to contact between molecules of any material. Different materials conduct heat at different rates, such as polystyrene coffee cups versus glass cups. Convective heat transfer is the result of the movement of gases, typically air, carrying heat energy.

THE TESTING SHOWS THAT THE COATINGS, EVEN AT THICKNESSES THAT ARE ABOVE THOSE TYPICALLY INSTALLED IN FIELD USE, ARE THREE TIMES LESS EFFECTIVE AS INSULATORS THAN ½ INCH OF MINERAL FIBER INSULATION.

The convection can be natural, caused by density differences in the gas at different temperatures, or it can be forced like wind blowing against a hot surface. Radiative heat transfer occurs through the exchange of energy waves between two bodies of different temperatures. The higher the temperature difference between the two bodies, the higher the heat transfer. A good example is the transfer of energy from the sun through the vacuum of space to

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earth. Radiant energy transfer can be enhanced or reduced through the energy emitting characteristics of the two surfaces. Certain surface treatments enhance energy transfer, others retard it.

Depending on the conditions that exist around a hot surface, the primary mode of heat transfer can vary. Most thermal insulations used today address all three modes of heat transfer. One exception to this is very low emittance surfaces such as bright foils. In this case, the foil can provide a fairly high amount of thermal resistance if there is no forced or natural air movement around the foil surface and as long as the foil retains its bright surface, untarnished by oxidation or dust build up.

So now the question is; how do the ceramic coatings provide superior thermal resistance in thicknesses of a few tens of thousandths of an inch? The literature for most of these products is less than clear on this topic. Some claim a very low thermal conductivity, while others allude to superior resistance to heat flow by radiation. How can a designer or owner compare the thermal performance and value of traditional insulation materials against the "high tech" ceramic coatings? To measure in-place performance on actual surfaces operating above ambient temperature, NAIMA hired an independent, NAVLAP certified testing laboratory to perform comparison tests under carefully controlled conditions.

...A CLOSER LOOK AT THESE COATINGS WILL CONFIRM THE OLD ADAGE, "IF IT SOUNDS TOO GOOD TO BE TRUE, IT PROBABLY IS."

Thermal Performance Testing Results

Two brands of commercially available coatings were tested over a range of temperatures and reasonable application thicknesses. An apparatus was designed and built to measure the heat loss from bare steel pipe and steel pipes coated with commercially available insulation products. The apparatus was able to determine the heat loss from a pipe with relatively thin thicknesses of coatings and a specimen of ½ inch thick mineral fiber pipe insulation.

Table 1: Coating Testing[1]

Description	Designation
Coating A at 0.053 inches (53 mils)	A 53
Coating A at 0.113 inches (113 mils)	A 113
Coating B at 0.0235 inches (23.5 mils)	B 23.5
Coating B at 0.0595 inches (59.5 mils)	B 59.5

Table 2: Comparison of Heat Flows from Insulated Pipes with Data from Bare Pipe

Del T (°F)	Heat Flow (Btu/ft²·h)					
	Bare	A 53	A 113	B 23.5	B 59.5	FG ½-in.
50	127.2	113.0	29.2	85.2	56.4	18.0
100	269.1	236.2	104.2	195.4	123.3	51.0
150	450.1	397.7	184.0	323.6	208.1	86.6
200	670.1	597.6	268.4	469.5	310.9	125.0
250	929.2	835.8	357.5	633.4	431.6	166.1
300	1227.3	1112.4	451.4	815.0	570.2	209.8
350	1564.4	1427.3	549.9	1014.6	726.9	256.2

Ambient temperature approximately 90°F

Table 3: Thermal Resistances Estimated from a Comparison of Measured Heat Flux Data and Heat Fluxes Calculated Using ASTM C 680

Pipe Insulation	Estimated Thermal Resistance (ft²·h·°F/Btu) (horizontal)[3]
Coating A (53 mils)	0.07
Coating A (113 mils)	0.57
Coating B (23.5 mils)	0.16
Coating B (59.5 mils)	0.46
½-in. mineral fiber	1.78

Process temperature 190°F and exterior air 90°F
Includes the exterior film resistance
Thermal Resistances are based on the heat flux at the pipe outside diameter

Each of the coatings was tested over a range of temperatures at two thicknesses, measured after each coating was fully cured. (See Table 1)

The heat flow across the exterior pipe surface is shown in Table 2 as a function of temperature difference. The heat flow for bare pipe and for the pipe insulated with ½ inch of mineral fiber insulation is also shown in Table 2.

Using the heat flow data shown above, the laboratory was able to estimate thermal resistance of both the coatings and the mineral fiber insulation. These estimates are shown in Table 3.

The testing shows that the coatings, even at thicknesses that are above those typically installed in field use, are much less effective as insulators than ½ inch of mineral fiber insulation.

LOWER TOUCH TEMPERATURE SHOULD NOT BE CONFUSED WITH EFFECTIVENESS AS A THERMAL INSULATOR.

Coatings Provide Low "Touch Temperature"

One of the strongest selling tactics used by some coatings manufacturers is that a person can readily sense a lower "touch temperature" when comparing a coated surface to an adjoining bare metal surface. People may draw the conclusion from this demonstration that the coating is a very effective insulator. In fact, while there will be a perceptible reduction in surface temperature due to the addition of a thin layer of any non-metallic material, much of the difference in "touch temperature" is due to the higher thermal diffusivity of the metallic surface compared to a non-metallic material.[2] Even at the same temperature, the higher thermal diffusivity of the metallic surface conducts heat more rapidly to the hand, making it feel warmer.[3]

WHILE IT 'FEELS' AS IF THE COATING IS INSULATING THE HOT SURFACE, THE COATING IS NOT NECESSARILY EFFECTIVELY REDUCING HEAT LOSS.

Lower touch temperature should not be confused with effectiveness as a thermal insulator. While it "feels" as if the coating is insulating the hot surface, the coating is not thick enough to provide meaningful reductions in heat loss. As shown in Table 2, the coatings tested had over twice the heat loss of compared to ½ inch of mineral fiber pipe insulation. These coatings would not be considered adequate by today's commercial energy standards, which require at least ½ inch of thermal insulation.[4]

Summary

Despite some outstanding thermal performance claims by some coatings manufacturers, there are no shortcuts when it comes to energy efficiency, protection against heat loss for process control, controlling condensation and reducing greenhouse gas emissions. Insulation system designers need to know that the insulation systems they specify will perform to the design spec for the life of the system. Also, the insulation material itself should be protected against water incursion to maintain the thermal value, and to keep the insulation pipes beneath corrosion free.

Some coatings manufacturers recommend applications consisting of one or two coats. A coat is defined by some manufacturers as having a thickness of approximately 20 mils (0.020 inch).[5] The testing reported here shows that to achieve thermal performance equivalent to ½ inch of mineral fiber pipe insulation, the minimum commercially available, significantly more than two coats would be required.[6]

INSULATION SYSTEM DESIGNERS NEED TO KNOW THAT THE INSULATION SYSTEMS THEY SPECIFY WILL PERFORM TO THE DESIGN SPEC FOR THE LIFE OF THE SYSTEM...

Arguably there may be some instances were coatings could be suitable for use – to lower burn potentials in some hard to insulate areas, for example. However, qualified insulation contractors are experienced in insulating the types of surfaces typically found with pipes and equipment.

References

1. Yarbrough, D.W., Measurement of Heat Loss from Coated and Insulated Steel Pipes, R&D Services Report, December 2008.

2. ASTM C 1057, Standard Practice for Determination of Skin Contact Temperature from Heated Surfaces Using a Mathematical Model and Thermesthesiometer, ASTM International, West Conshohocken, PA

3. Ibid

4. ASHRAE Standard 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, GA

5. Ibid

6. Hart, Gordon H., Thermal Insulating Coatings, Insulation Outlook, July, 2006.

About NAIMA

NAIMA is the association for North American manufacturers of fiber glass, rock wool, and slag wool insulation products. Its role is to promote energy efficiency and environmental preservation through the use of fiber glass, rock wool, and slag wool insulation, and to encourage the safe production and use of these materials.

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