



CONSIDERATIONS FOR THIN BLANKET INSULATION IN INDUSTRIAL APPLICATIONS

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INTRODUCTION

Thin blanket industrial insulations are a relatively new introduction to the industrial market. They deliver thermal performance that is competitive with traditional insulations, but in a fraction of the thickness. In industrial applications, where space constraints can be a substantial hurdle, thin blanket insulation products can be a game-changer.

Thin blanket insulations have a low profile, flexibility, hydrophobicity, and high-temperature insulating properties which make them ideal for many industrial applications, and these characteristics have increased the demand for thin blanket insulations in recent years. That said, their comparative “youth” leaves a limited amount of information regarding how the materials perform in long-term, real-world applications. While we have historical evidence of the performance of traditional insulations that have been in use for decades, we must rely heavily on laboratory tests to help ensure that thin blanket insulations perform as desired.

Given that, it is crucial to understand the nuances of these test methods, and the products themselves, in order to specify a material that can best meet the needs and requirements of your application. At Johns Manville, we strive to ensure the insulating materials we offer are robust enough to withstand the rigors of the applications for which they are recommended. We put our materials through advanced testing, often times beyond that which is required by the standard specification for the material, to ensure our insulations will withstand the typical demands of the industrial applications where they are used.

The testing and use of thin blanket insulations is addressed in this eBook. We dive into the details of corrosion under insulation (CUI), hybrid systems, hydrophobicity, vibration, thermal performance, drying wet insulation, and thin blanket installation practices.

CHAPTER 1: CORROSION

NOT ALL PASSING RESULTS ARE CREATED EQUAL: UNDERSTANDING ASTM C1617

Corrosion under insulation (CUI) is a major concern for the industrial industry, and rightly so. The average cost of corrosion in the U.S. was estimated at more than \$1 trillion in 2013¹, and as time marches on, that number is continuing to grow. Industrial engineers, contractors, and facility owners and operators work diligently to mitigate corrosion in their facilities before it becomes an insurmountable problem or causes catastrophic damage.

This takes the form in careful installation practices (such as covering the pipe surface before it has been jacketed), regular, rigorous maintenance schedules, and specifying insulations designed to help inhibit corrosion. Often, the best method to addressing CUI is to preempt it in the design phase by treating corrosion is an eventuality rather than a possibility. This is done by selecting insulating materials that are hydrophobic, water-resistant, have a low corrosive potential, offer a corrosion inhibitor, or a combination thereof. These types of insulation include InsulThin® HT microporous thin blanket, silica aerogel thin blanket, Sproule WR-1200® expanded perlite, and Thermo-1200™ calcium silicate.

The corrosive potential of an insulation is commonly measured using the test ASTM C1617: *Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals*. ASTM C1617 measures whether or not an insulation material causes corrosion at a higher or lower rate than three control substances: the least corrosive, deionized water (DI), 1ppm chloride (Cl), and the most corrosive, 5ppm Cl. By determining how the tested insulation compares to the controls, one can rank the corrosive potential of different materials using the ASTM C1617 test method.

The outcome of the ASTM C1617 test provides us with the figures we need to determine whether or not an insulation material meets its material specification. Material specifications such as ASTM C1676: *Standard Specification for Microporous Thermal Insulation* or ASTM C1728: *Standard Specification for Flexible Aerogel Insulation* state the specific test results needed to meet each individual material standard.

It's important to note that while these materials are measured using the same test method, the standard specifications for differing materials do not have the same requirements. These material specification standards are typically published on data sheets as *pass/fail*, and if we strictly consider insulations based on their pass/fail results and not the actual test results or material category, we could easily and inaccurately conclude that each *passing* insulation has equivalent corrosive potentials.

However, the material specification standards are unique to each insulation, and some standards require an insulation to have a lower corrosive potential than others. For example, the *pass* designation in the ASTM C1676 standard for microporous blanket insulation requires the insulation to be less corrosive than deionized water, the least corrosive standard reference. At the opposite end of the spectrum, the ASTM C1728 *pass* designation for silica aerogel blankets is a corrosion rate that is lower than 5ppm Cl, the most corrosive control substance in ASTM C1617 (Table 1, next page).

1. <https://www.g2mtlabs.com/corrosion/cost-of-corrosion/>

Table 1: Material Standard Requirements for Corrosive Potential for InsulThin HT and Silica Aerogel Blankets

	ASTM C1676 Microporous Blanket Insulation (InsulThin HT)	ASTM C1728 Flexible Aerogel Insulation
Material Standard Requirement Using ASTM C1617 Test Method	Less than DI <i>*least corrosive reference</i>	Less than 5 ppm Cl <i>*most corrosive reference</i>

Table 1: Silica aerogel has a higher corrosive potential than InsulThin HT as demonstrated in the ASTM C1617 test. If they were both held the standard specification, ASTM C1676 for microporous blankets, silica aerogel would be unlikely to pass.

In other words, though both InsulThin HT and silica aerogel blankets may meet their individual ASTM standard specification requirements, each material's corrosive potential requirements are distinct to that material. It can often be misleading to compare the two materials by their pass designation, as their corrosive potentials are substantially different. For example, each of the materials in Table 1 pass their standard specifications, but ASTM C1617 has demonstrated that their corrosive potential varies widely.

Unless you are armed with the knowledge that the passing standard varies depending on the type of insulation material, the corrosive potential of each insulation material can appear to be similar or even equal. During the design phase, making this assumption can be a crucial blunder that could potentially put your system at risk for CUI. To ensure you have a full picture of the insulation's performance, beyond simply a pass/fail rating, you can reach out to the insulation manufacturer about the data presented in their data pages to clarify the exact performance of the insulation.

LONG-TERM CORROSION UNDER INSULATION TESTING

While ASTM test methods have proven to be a relatively reliable source for insulation performance, industry professionals have recently begun to express concerns that they don't account for the myriad of variables that are encountered in real-world conditions. While lab testing is designed to isolate variables, real-world applications rarely have isolated systems. Influencers like weather, operating temperatures, relative humidity, the jacketing, pipe, and insulation all play a role in promoting or inhibiting corrosion.

With that in mind, end-users partnered with a third-party research agency to develop a new test protocol that more accurately represents what would be encountered in the real world. This new test protocol simulated a "real-world" application by testing corrosion on a complete system (pipe, insulation, and jacketing) in an environment designed to accelerate corrosion. While the test was originally designed to measure the corrosion-inhibiting performance of coatings, it was adapted to measure the corrosive potential of insulation by removing the coatings from the test assemblies.

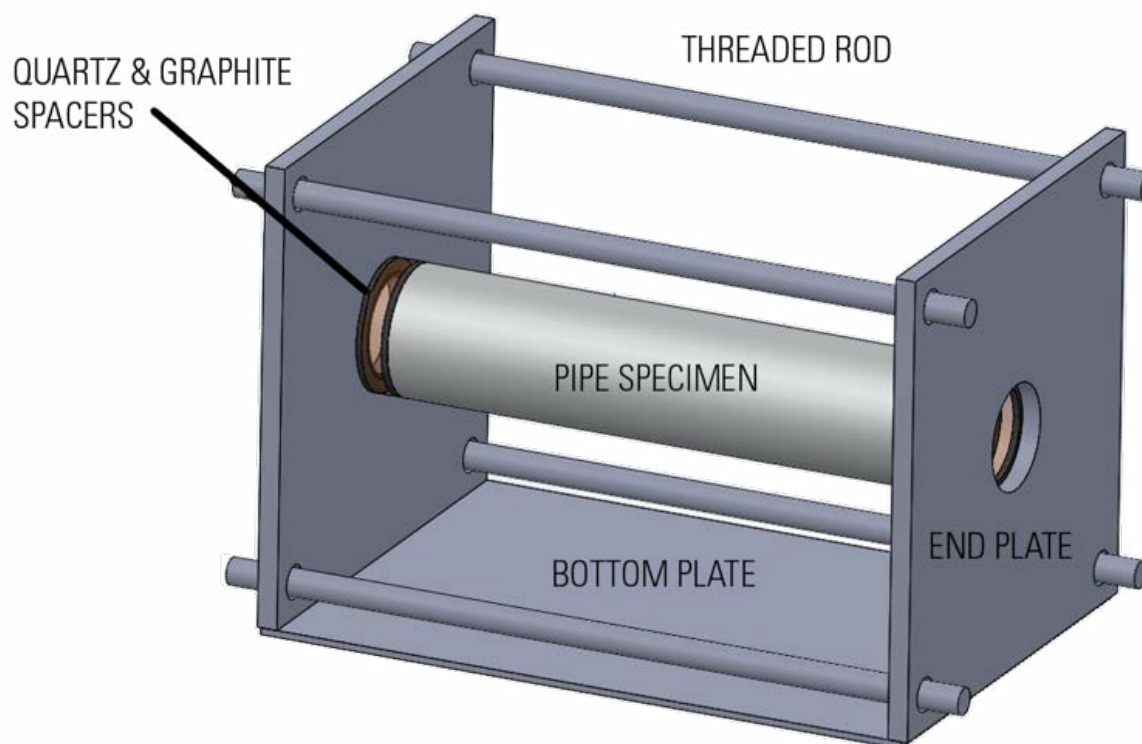
The program's objective was to test how insulations perform in "real-world" installation and environmental conditions by using carbon steel pipes insulated with InsulThin HT or silica aerogel blanket insulation specimens and clad with aluminum jacketing. These assemblies were exposed to harsh environmental conditions designed to accelerate and promote corrosion. As this test was designed to replicate "real-world" conditions, the testing period lasted for 6 months, during which the assemblies were consistently exposed to highly corrosive environments. At the conclusion of 6 months, the third-party agency

analyzed the results and compared them to laboratory data based on ASTM standard specifications.

Test Apparatus:

Both materials were wrapped, double-layer, around 2" carbon steel pipes and secured with a metal cladding, and then each assembly was exposed to two different environmental conditions (Figure 1).

- **Condition 1** – Cycling Conditions: assemblies were cycled between ambient and 600°F (315.5°C). Between each cycle, the test assemblies were submerged in the tap water/chloride solution to cycle the assembly between wet and dry conditions.
- **Condition 2** – Sweating Conditions: assemblies were kept wet, at 45°F - 65°F (7°C – 18°C) for the course of 6 months.



NOTE: SIDE PLATES NOT SHOWN

Figure 1: Cross-section of the test tank. The tank was filled with tap water/1500 ppm chloride water, per the test requirements, to submerge the assembly completely.

For each of the four test protocols (two insulations x two environmental conditions), corrosion rates and depths were calculated using an electrochemical method. After the testing was complete, the corrosion depths were then measured using an ultrasonic technique and with the use of an optical microscope. The measurements were compared to results from laboratory ASTM tests using the same two insulations on carbon steel. Interestingly, the conclusions from the third-party agency’s report are consistent with the findings from the ASTM test methods, and they include the following:

- At constant, low-temperature (45°F conditions), InsulThin HT and the tested silica aerogel blanket specimen have similar corrosion rates and depths.
- At high-temperature cycling conditions (between ambient and 600°F), InsulThin HT has lower corrosion rates and depths compared to the tested silica aerogel blanket specimen (Table 2).

Table 2: Mean Corrosion Depths Measured by Electrochemical Methods After High-temperature Cycling Conditions

Insulation	Mean Corrosion Depth (µm)	
	Two Months in Non-Chloride Solution	Four Additional Months in Chloride Solution
Johns Manville’s InsulThin HT	7	213
Tested Silica Aerogel Blanket Specimen	91	1396

Table 2: Mean corrosion depths after 6 months of exposure to high-temperature cyclical conditions. The tested silica aerogel specimen shows substantially deeper corrosion depths than the InsulThin HT insulation.

- Deep, localized pitting is more significant at high-temperature conditions with the tested silica aerogel blanket specimen than it is with InsulThin HT (Figure 2).

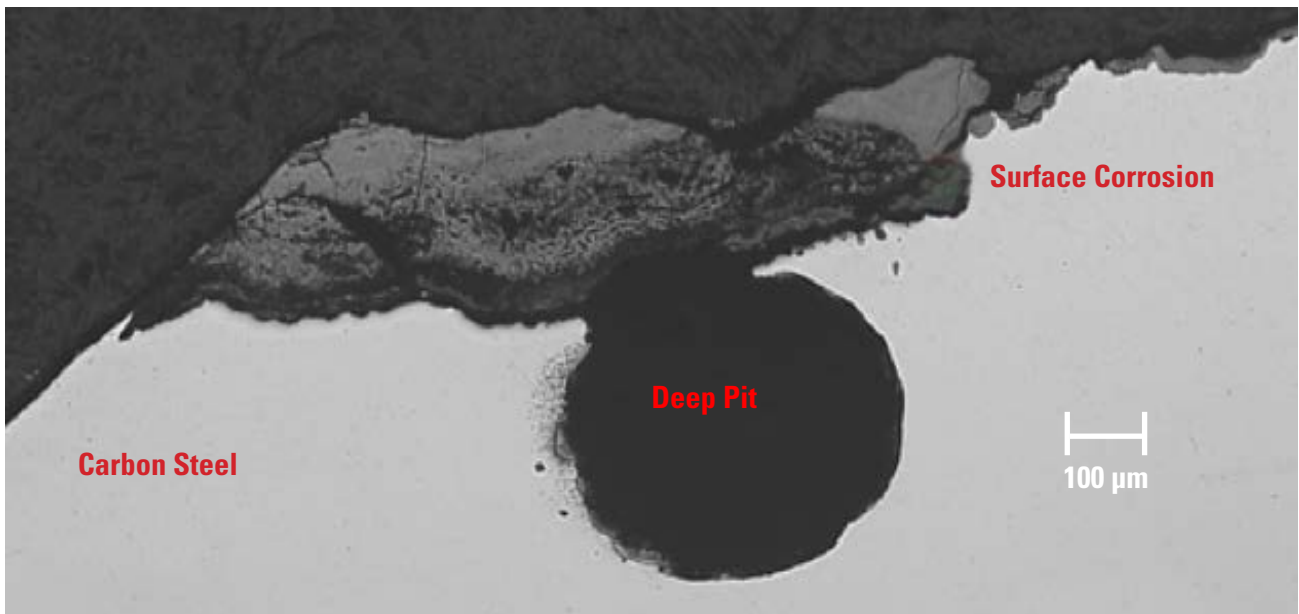


Figure 2: Optical cross-section of a carbon steel surface under the tested silica aerogel blanket insulation specimen after high-temperature cycling conditions showing deep, localized pitting. Deep, localized pitting is more concerning than uniform shallow pits.

It is our view that the testing reveals that InsulThin HT results in less corrosion than the tested silica aerogel blanket specimen in accelerated corrosion environments. This test program also provides support that the ASTM test methods currently being used by the insulation industry can be a good representation of real-world environments, and the findings are consistent with the laboratory results we find using ASTM test methods.

As we continue to explore the best methods to prevent CUI in industrial processes, evolving existing insulation test methods to account for real-world conditions is critical. This is why a protocol that studies the long-term effects of highly corrosive environments on insulated assemblies is, in our view, a more comprehensive look at how insulations will perform in real-world applications.

HYDROPHOBICITY & HYBRIDS

It may be tempting to assume that utilizing a hydrophobic blanket insulation, like InsulThin HT or silica aerogel blankets, will be sufficient to address CUI, but it's important to remember that hydrophobicity is not a panacea solution for CUI. While hydrophobic treatments do help prevent water from penetrating into the system, most hydrophobic treatments are silicone-based additives and organic in nature. Most silicone-based hydrophobic treatments begin to burn off around 450°F and have an upper temperature limit of 600°F. When exposed to these temperatures, silicone-based hydrophobic treatments will burn off and become ineffective.

For systems that operate at temperatures above 450°F, any outer layers of insulation will likely remain hydrophobic as insulation systems are usually designed to prevent surface temperatures from reaching such extremes, however the inner layer that is next to the pipe will likely lose its silicone-based hydrophobicity. While it may seem that having a single layer of hydrophobic insulation is sufficient to protect the pipe, designers should reconsider this perspective. If any damage is done to the system that compromises the outer layer, the inner layer may be susceptible to water infiltration or absorption. As such hydrophobic insulations should not be considered the be-all-end-all solution for CUI prevention, but rather one component of a robust CUI-prevention strategy.

To account for the loss of hydrophobicity at such high temperatures, designers could consider utilizing a hybrid system. Hybrid systems layer two different types of insulation to capitalize on the benefits of both. An example of a hybrid system would be specifying a thin, hydrophobic blanket, like InsulThin HT, over an insulation with high compressive strength and corrosion inhibitors, like Thermo-1200™ calcium silicate or Sproule WR-1200 expanded perlite. While the base layer of Thermo-1200™ or Sproule WR-1200 would be expected to lose their hydrophobic or water-resistant treatments at 450°F+ temperatures, they each have a proprietary corrosion inhibiting formula, XOX Corrosion Inhibitor®, that is not affected by the operating temperature of the system. Thus, even if the hydrophobicity of the base-layer burns away, it will still have a hydrophobic outer layer and a corrosion-inhibiting inner layer to help protect the pipe. Additionally, a hybrid system, like the one described above, would capitalize on the thin, space-saving benefits of InsulThin HT and the compressive-strength and corrosion inhibitors of Thermo-1200™ or Sproule WR-1200.

CHAPTER 2: THERMAL PERFORMANCE

InsulThin HT is ideal for industrial applications that range from ambient to 1200°F. While it offers excellent, consistent thermal performance at high temperatures, InsulThin HT should not be used for cryogenic applications. Other insulations, like cellular glass or some faced silica aerogel insulations are more appropriate for cold temperature applications. In this eBook, we will solely be considering the thermal performance of high-temperature insulations.

Before selecting or specifying a thin blanket material, there are key details to consider to ensure insulation systems operate as designed: thermal shift, application surface geometry, and the number of layers required to achieve the desired performance. These key features are crucial to not only ensuring that the system is designed correctly, but that installation is optimized, and the desired process control is achieved.

THERMAL SHIFT

Thermal shift is a relatively new finding in the industrial industry, and it refers to the permanent change in an insulation's thermal performance due to exposure to high temperatures. Studies have found that thermal shift only affects silica aerogel blanket insulation; other tested insulations have not demonstrated the same thermal instability. In the tests, when the silica aerogel was exposed to temperatures that exceed 300°F for prolonged periods of time, the aerogel within the insulation began to fracture, permanently compromising the material's thermal performance (Figure 3). This decrease in thermal performance is called thermal shift.

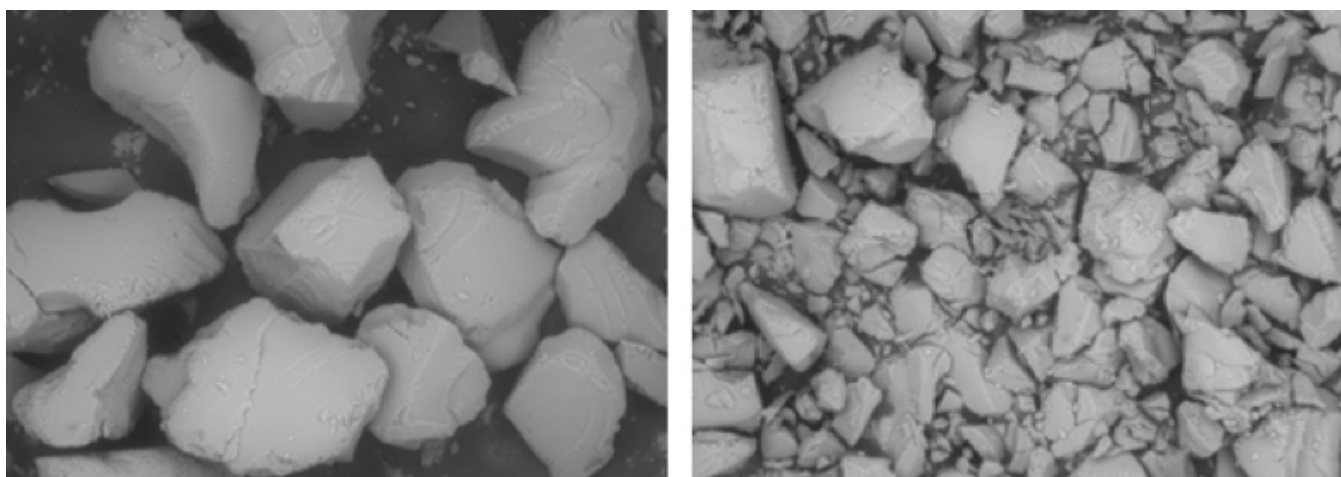
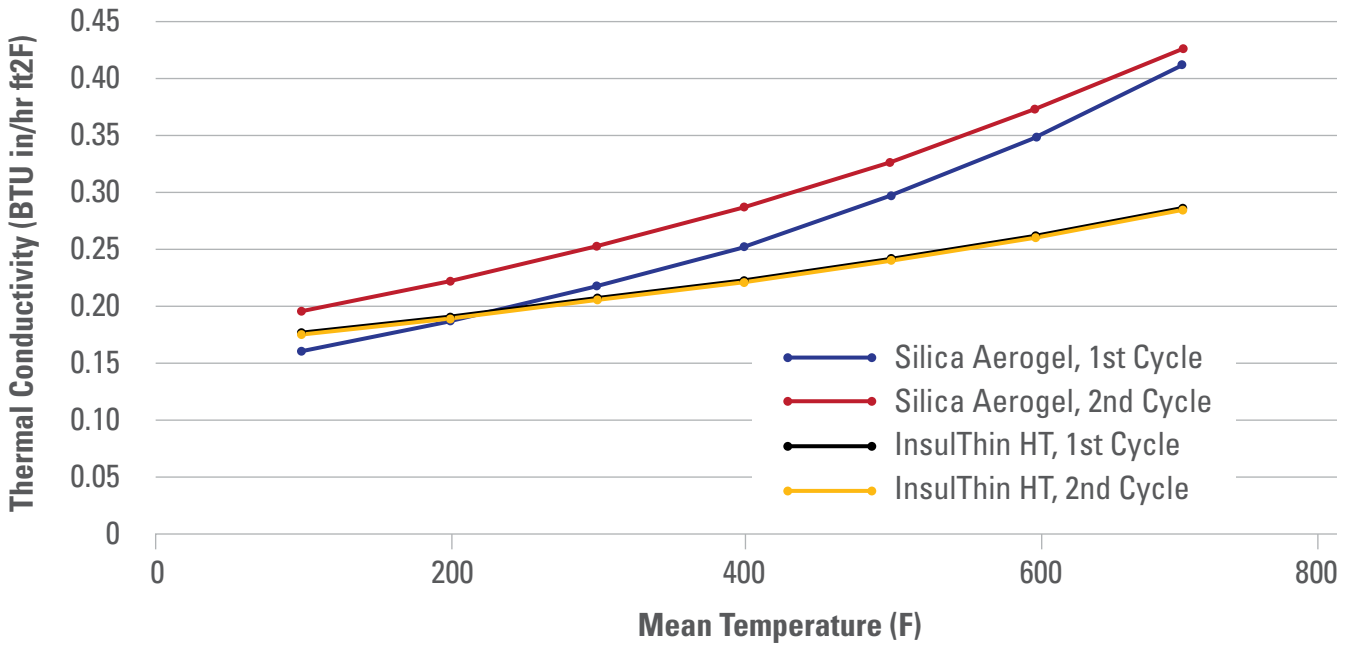


Figure 3: Microscopic view of silica aerogel particles before thermal shift (left) and after thermal shift (right). The fractured particles fill the air pockets between the particles which is what causes the decrease in thermal performance.

In some cases, silica aerogel may see as much as a 20% decline in thermal performance, allowing more heat to pass through the insulation than the system was designed to allow (Graph 1). This impacts system’s efficiency, process control, and personnel safety.

Graph 1: “Shifted” Thermal Conductivities of Tested Silica Aerogel Blanket Specimen



Graph 1: Thermal conductivity values for InsulThin HT and a silica aerogel blanket specimen tested via ASTM C335 before (1st cycle) and after (2nd cycle) thermal shift. Note the thermal conductivity values for InsulThin HT do not vary between the first and second cycle.

While thermal shift can be seen over the course of a short-term test, the findings from the long-term test protocol also captured the thermal shift of the silica aerogel specimen (Table 3).

Table 3: External Metal Sheathing Temperatures of InsulThin HT and the Tested Silica Aerogel Blanket Specimen Throughout the Long-Term Test Protocol

Insulation	External Metal Sheathing Temperature (°F)				
	1 week	3 months	6 months	3E Plus	3E w/shift
Johns Manville InsulThin HT	158	159	164	160	160
Tested Silica Aerogel Blanket Specimen	177	185	191	169	177

Table 3: External metal sheathing temperatures for InsulThin HT and the tested silica aerogel blanket specimen at different times after repeated wet/dry and high-temperature cycles. NAIMA 3E Plus software modeling values using ASTM 335 (pipe geometry) data for the conditions tested before and after thermal shift are shown for comparison.

Fortunately, studies have shown that the thermal degradation of the tested silica aerogel is not infinite. The material will degrade to a certain point at which it will begin to maintain consistent thermal performance once

again. As a result, thermal shift can be addressed in the design phase by adding additional layers of silica aerogel insulation to the system design.

In our view, the test results reveal critical data for professionals to consider when designing insulation thicknesses and attempting to minimize labor and material costs. Depending on the requirements of the application and the environmental conditions of a project, additional silica aerogel insulation may be required if calculations are based on the shifted, “in-use” thermal conductivity values, rather than the manufacturer’s published “before-use” thermal conductivity values. Designers may also address thermal shift by using insulations like InsulThin HT, calcium silicate, expanded perlite, or mineral wool instead of silica aerogel, on systems that operate at temperatures over 300°F.

SYSTEM CONFIGURATIONS: FLAT VS. ROUND

While it may be easy to assume that the thermal performance of an insulation system depends solely on the operating temperatures of the application and the k-value of the insulation, designers also need to consider the surface geometry of the application. What many designers don’t realize is that the installed thermal conductivity



Figure 4: Heat flow meter used to measure the transfer of heat through the insulation for ASTM test method C518. Designed for boards, blankets, & blocks.

properties of an insulation vary depending on whether it’s used to insulate a flat or round (pipe) surface. These differing results are clearly visible when the insulation’s thermal performance is tested via the ASTM C518: *Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus* and ASTM C335: *Standard Test Method for Steady-State Heat Transfer Properties of Pipe Insulation*.

When tested via the ASTM C518 (flat) test method, the insulation is compressed between two plates. One plate is heated to operating temperatures for several hours to determine how much heat passes through the insulation to reach the bottom plate (Figure 4). This heating environment typically represents a best-case-scenario for insulation applications, and the results should be used when designing systems that use boards, blankets, and blocks for flat-surface applications.

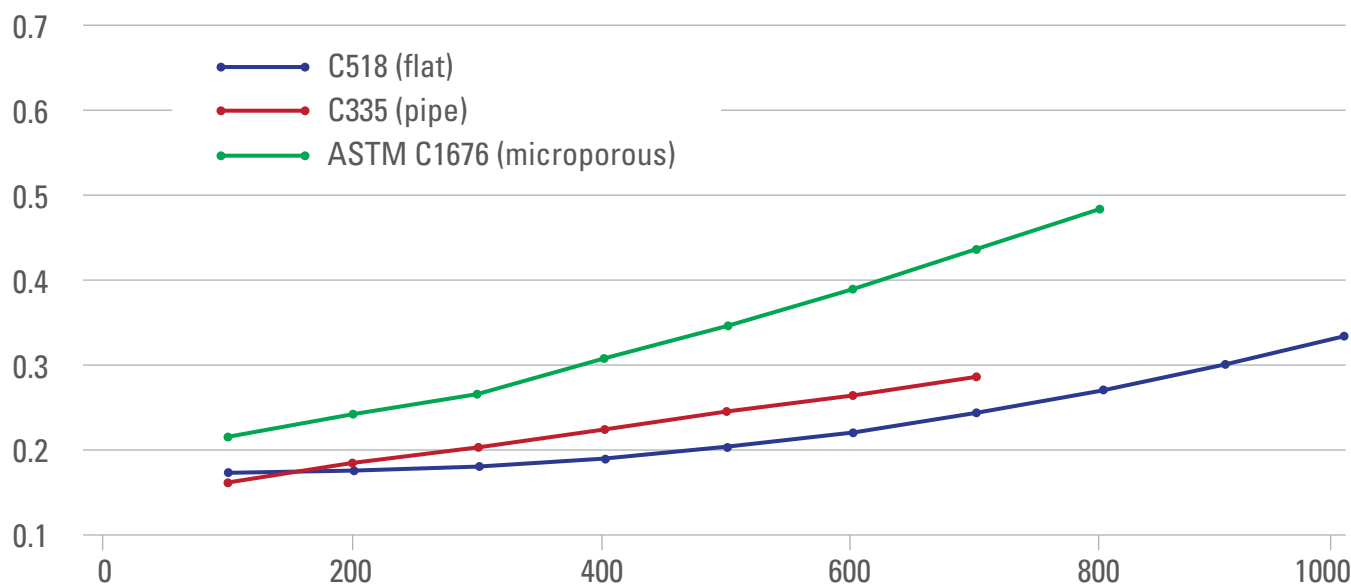
However, in the real world, insulations are not simply applied to flat geometries. In order to fully comprehend an insulation's installed thermal performance, it must also be tested via the ASTM C335 (round/pipe) test method. This method installs the insulation on a pipe, which is then heated to a steady operating temperature for several hours (Figure 5). Control guards are put in place at each end of the pipe to ensure the temperature remains consistent and the heat flows outward rather than longitudinally. This helps ensure the test method is indicative of a field application. In this environment, many insulations see a drop in thermal performance.



Figure 5: Guarded end apparatus used to measure the transfer of heat through the insulation for ASTM test method C335. Designed for pipe insulation.

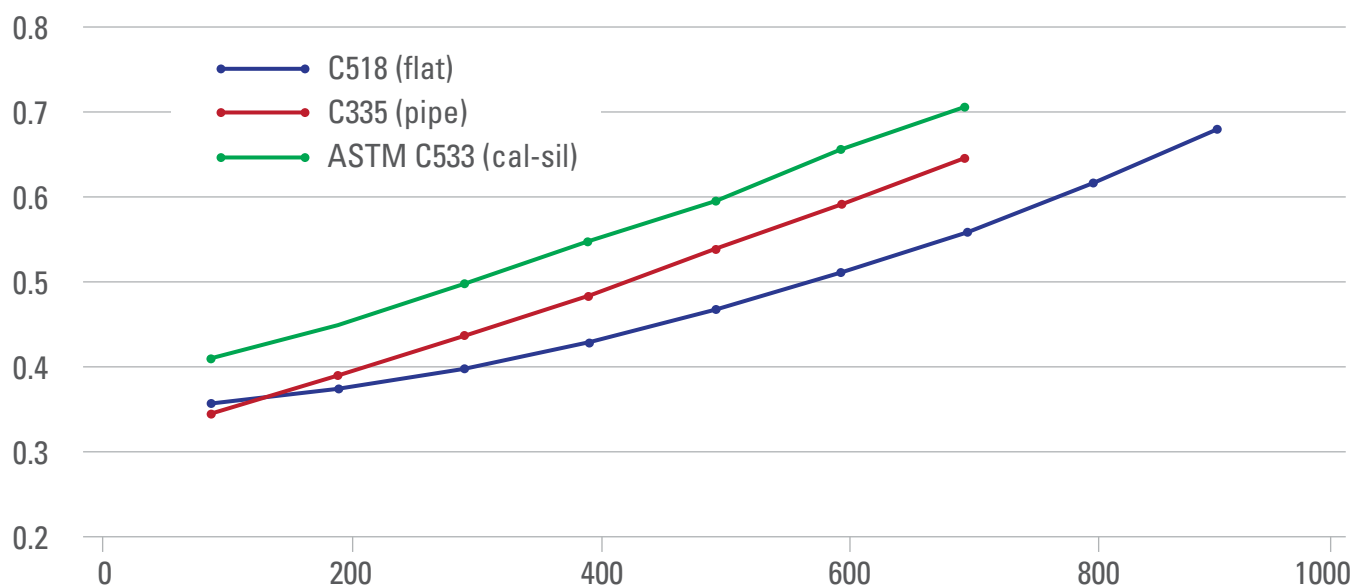
The temperature discrepancies between these two test methods are substantial (Graph 2, 3, 4, & 5), and if not accounted for in the design phase can impact the thermal performance of the system as a whole.

Graph 2: InsulThin® HT Microporous Blanket Round & Flat Thermal Conductivities



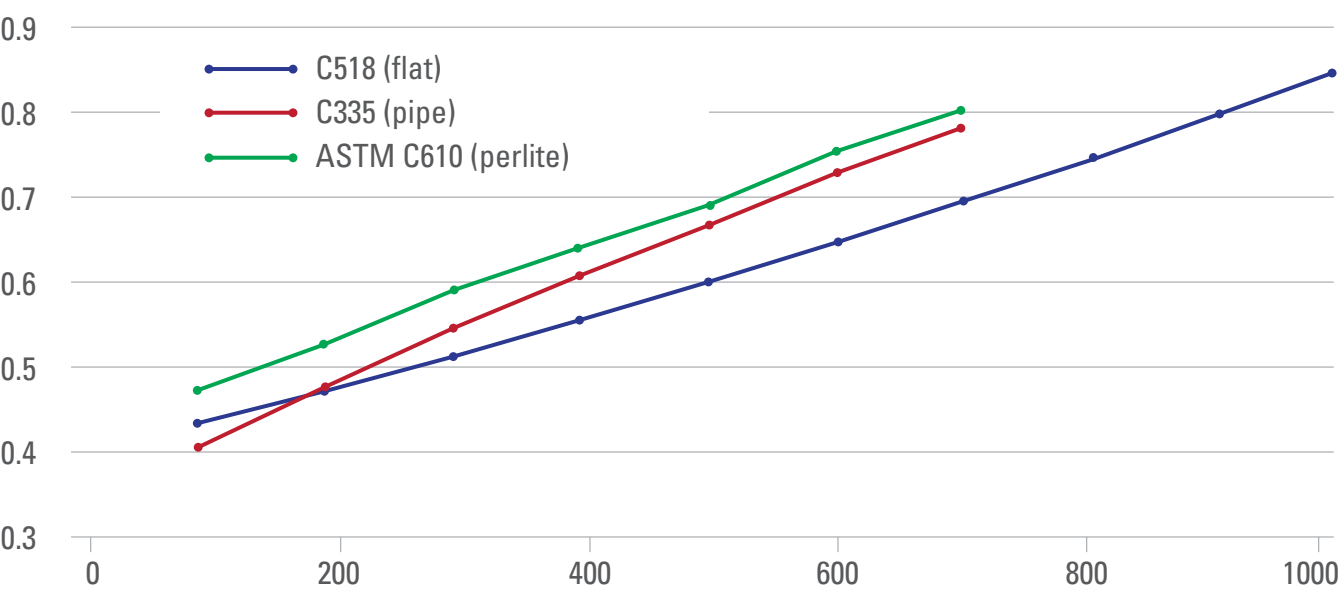
Graph 2: InsulThin HT microporous blanket thermal conductivities during ASTM C518 and ASTM C335 test methods. The standard specification for microporous blankets, ASTM C1676, is also shown for comparison.

Graph 3: Thermo-1200™ Calcium Silicate Round & Flat Thermal Conductivities



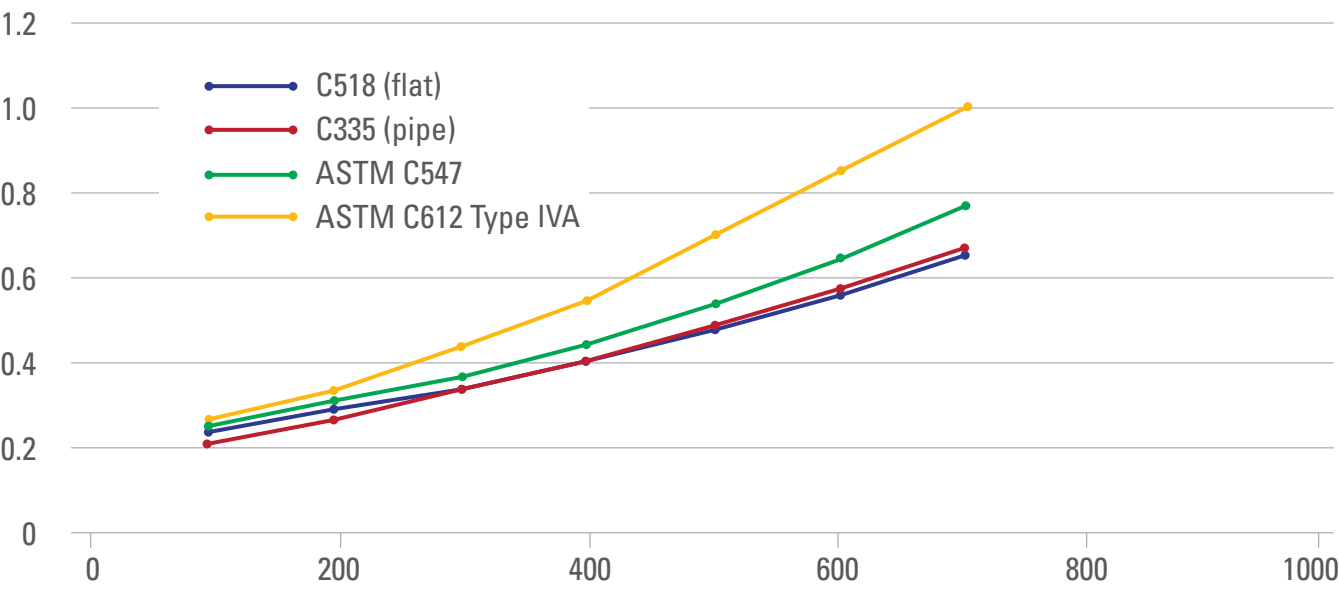
Graph 3: Thermo-1200™ Calcium silicate thermal conductivities during ASTM C518 and ASTM C335 test methods. The standard specification for calcium silicate, ASTM C533, is also shown for comparison.

Graph 4: Sproule WR-1200® Expanded Perlite Round & Flat Thermal Conductivities



Graph 4: Sproule WR-1200 Expanded perlite thermal conductivities during ASTM C518 and ASTM C335 test methods. The standard specification for expanded perlite, ASTM C610, is also shown for comparison.

Graph 5: MinWool-1200® Mineral Wool Round & Flat Thermal Conductivities



Graph 5: Mineral Wool thermal conductivities during ASTM C518 and ASTM C335 test methods. The standard specifications for mineral wool, ASTM C547 and ASTM C612 Type IVA, are also shown for comparison.

The discrepant results are caused by differences in installation and heat transfer properties between flat and round geometries. Using flat data for a pipe application could result in higher heat loss as well as higher surface temperatures than expected. Instead, it may be necessary to install additional insulation layers to achieve the desired thermal performance on a round pipe. Unlike thermal shift, the disparate values in thermal performance between flat and round geometries are consistent across all insulations, and should be addressed when designing and specifying insulation systems.

Bear in mind some manufacturers only publish the flat-surface data (ASTM C518) on their data sheets. If you need the data from ASTM C335 for a round surface application, and it is not on the material's data sheet, reach out to the manufacturer to acquire the information before designing the insulation system. When it comes to thermal performance, it's crucial to know whether the data you have been provided comes from ASTM C518 or ASTM C335. Capturing the relevant variables and understanding the intricacies of how the product performance specifications were calculated is critical to ensuring the performance you expect in real-world applications.

INSULATION THICKNESS & LAYERS:

In terms of energy efficiency and process control, one of the primary factors that dictates thermal performance is insulation thickness. Ultimately, once installed, all insulation materials will have specific thermal requirements they need to achieve; the primary difference among the materials in terms of thermal performance comes down to how thick they need to be in order to maintain these required temperatures, and in many cases, multiple layers of insulation will be necessary to achieve the desired performance.

This is where it's important to understand the competitive thermal conductivities of each insulation – whether it's thin blanket insulation or pre-molded insulation. The table below indicates the required thickness for several types of insulation to achieve safe-to-touch temperatures (140°F as recommended by ASTM C1055: *The Standard Guide for Heated system Surface Conditions that Produce Contact Burn Injuries*) on a 600°F pipe* (Table 3). It includes the number of layers of insulation that would be required to achieve the appropriate thickness for the necessary thermal performance.

Table 4: Insulation Thickness and Number of Layers Required to Achieve Safe-to-Touch Surface Temperatures

Insulation Material	Pipe Temperature: 600°F		
	Thickness (in)	Thickness (mm)	Layers
Calcium Silicate	2.5	64	2 Layers
Expanded Perlite	2.5	64	2 Layers
Mineral Wool	2.0	84	2 Layers
Silica Aerogel	1.2	30	3 Layers
Silica Aerogel (post thermal shift of tested silica aerogel blanket)	1.4	35	4 Layers
Microporous Blanket	1.0	25	3 Layers

* Tested using ASTM C335: 12" pipe/ambient air temp 75°F/jacketed ($\epsilon = 0.10$)/ wind speed = 2.5 mph

Table 4: Insulation thickness requirements to achieve safe-to-touch temperatures on a 600°F pipe. While the thin blanket insulations require less thickness overall, it typically takes more layers to achieve the necessary thickness than the pre-molded insulations. This becomes a significant factor at higher temperatures where thin blanket insulations may require substantially more layers to achieve competitive thermal performance.

As you compare the products, you'll see that calcium silicate and expanded perlite require a total thickness of 2.5 inches on a 600°F pipe. This can be achieved in 2 layers of insulation. In contrast, while InsulThin HT microporous blanket only needs to be 1 inch thick and silica aerogel only needs to be 1.4 inches thick (after thermal shift), it takes 3 layers of InsulThin HT and 4 of layers silica aerogel (accounting for anticipated thermal shift) to achieve the necessary thickness for the application.

Though the thin blanket insulations may only require a fraction of the thickness to achieve the necessary thermal performance, designers should keep in mind that any time additional layers are needed there will be added cost for both installation labor and materials. This is where a trade-off comes in, and where designers should consider the unique requirements of their applications to ensure they select the material with the right performance characteristics for their needs. If the application has space constraints, then multiple layers of a thin blanket may be the more appropriate choice; however, if space constraints are not a concern, system designers may consider using a pre-molded insulation as a more economical solution.

CHAPTER 3: WEEP HOLES

NOTE: After any major flooding or extreme weather event that has likely damaged the insulation, Johns Manville always recommends stripping and replacing any flooded/damaged insulation as soon as possible. This can help prevent CUI, allow for detailed pipe inspection, and ensure that contaminated water does not cause further damage to the pipe or the insulation. Furthermore, saturated insulation decreases in thermal performance. Insulation must be dry for it to perform as indicated on the manufacturer's data sheets and as specified by the system designer.

Flooding and strong, wind-driven rain events have historically been a thorn in the side of installers, designers, and engineers specifying insulation systems. Some specifiers choose to approach these extreme weather events by simply specifying a hydrophobic insulation, under the assumption that the hydrophobicity will prevent water ingress. However, this approach is sometimes too simplistic to appropriately account for the potential for water ingress, as hydrophobic insulations are not a cure-all solution to preventing water from contacting the pipe.

At temperatures of 450°F and above, insulations with a silicone-based hydrophobic treatment lose their ability to repel water as the silicone oxidizes and burns off. An insulation that may bead water at 300°F can become absorptive after exposure to temperatures of 450°F or higher. When this happens, most hydrophobic industrial insulations actually become a hybrid of hydrophilic (absorptive) and hydrophobic². Typically, the insulation will become hydrophilic next to the pipe, where the hydrophobe has been burned away, and hydrophobic at the outer portion of the insulation, where the hydrophobic agent is still intact.

Rather than relying on hydrophobic insulation as a cure-all, a better approach for high-temperature applications would be to design the insulation system around an assumption that water will eventually enter the system. With this approach, designers can preemptively address water ingress by creating a means for the water to exit the system quickly once it has been absorbed by the insulation; in this case, we are specifically talking about specifying weep-holes in the jacketing and adding extra insulation to improve the thermal value of the insulation system.



Figure 6: $\frac{3}{4}$ " weep hole drilled into jacketing to promote water drainage from a saturated system

While relying on the heat of the pipe should be a facet of the designed "drying plan," designers should also consider specifying drainage holes in the jacketing. The reason being that even though most industrial insulations are "vapor open," meaning they allow water vapor to pass through them, the jacketing is not. This means that any water vapor that is pushed out of the insulation by the heat of the pipe will become trapped in the system by the jacketing. This is where the drainage holes, or "weep holes," come in to play as they allow an easy path for moisture to escape (Figure 6).

² Insulations that are inherently hydrophobic and not treated with a silicone-based hydrophobic treatment, like cellular glass, will remain water-repellent up to the maximum use temperature.

System designers can also preempt water intrusion by adding an extra layer of insulation to increase the thermal value of the system, in *addition* to specifying weep holes. This sets up the system to optimize the drying process because it increases the thermal value of the system, retaining heat and expediting the drying process.

To explore how much an additional layer of insulation could influence drying times, we ran a test on saturated Thermo-12® Gold*. In the test, 3' x 1.5" sections of Thermo-12 Gold calcium silicate pipe insulation were saturated with water and installed on a room-temperature pipe. This layer of calcium silicate was then covered by a 10 mm layer of InsulThin HT, and the insulation system was jacketed with stucco embossed aluminum jacketing with 3/4" weep holes spaced 36" on center. The ends of the insulation and jacketing were sealed to prevent moisture from escaping. Then the pipe was heated to 600°F, and the temperatures of the pipe, insulation, and jacketing were recorded.

For a control, the test was repeated on two different configurations (in addition to the dual-insulated configuration): one without the external InsulThin HT layer but with jacketing weep holes, and one without the InsulThin HT or the jacketing weep holes. Results of the testing are shown in the Table 4.

Table 5: Dry-time Duration

Configuration	Pipe Time to 600°F	Insulation Time to Dry
Thermo-12 Gold, InsulThin HT, Weep Holes	4.2 hrs	24 hrs
Thermo-12 Gold, Weep Holes	4 hrs	55 hrs
Thermo-12 Gold, No Weep Holes	26 hrs	>100 [†]

[†] After 100 hours, the test was halted even though the insulation was not yet dry.

Table 5: The number of hours it took each system to reach 600°F and for the insulation to dry out entirely. In the configuration without the jacketing weep holes, the system took over a day to reach 600°F and the insulation did not dry before the test was halted (100 hours).

As anticipated, the weep holes reduced the drying time by allowing a path for water to escape. Furthermore, adding InsulThin HT to the system in addition to weep holes, **reduced the drying time by more than 75%**, dropping it from over 100 hours down to 24 hours.

Clearly, the use of a thin, hydrophobic blanket provides additional protection against water intrusion, but this study has shown that it can also help after water has entered the system. Adding extra thermal value to the insulation system via an additional layer of insulation retains heat and expedites the drying process. Ultimately, this can make a substantial difference in the drying time which can help prevent CUI after a water-intrusion event.

* Thermo-12 Gold, Johns Manville’s legacy calcium silicate, was used for this study because of its existing prevalence in the industry.

CHAPTER 4: VIBRATION

High-temperature, industrial insulations often operate in physically demanding environments that would melt, shatter, or otherwise destroy other types of insulating materials such as plastics, fiberglass, or foam rubber. These environments not only reach extreme temperatures, but they can also be rigorously demanding as a result of heavy vibration caused by the proximity and concentration of motors, valves, and high-pressure steam. In these kinds of environments, higher than normal levels of vibration are part of the design equation that engineers or specifiers must consider.

Most high-temperature insulations are molded from minerals or mineral fibers. In a typical industrial application, many of these products can last for decades when properly installed and maintained. However, when the application includes high levels of vibration, the stress on the insulation increases substantially, limiting the types of insulating materials that would be suitable for the application and potentially shortening the lifespan of the insulation itself.

As a result, insulation used in high-vibration applications can often be limited to metal-mesh reinforced mineral wool, calcium silicate, or thin blanket insulations. Each of these insulations has unique features that make them applicable for applications with excessive vibration.

Mineral wool, for example, has excellent acoustical performance. This property can help protect employees' hearing by lowering what would otherwise be considered dangerous noise levels (as deemed by OSHA standards). This can be a critical feature for applications where facility workers are working around pipes or vessels that are generating excessive amounts of noise. However, in application with a lot of vibration, mineral wool's insulating performance hinges on the insulation's binder remaining intact. This can become problematic when operating temperatures reach or exceed 450°F, as the binder will begin to oxidize and burn off, jeopardizing the structural integrity of the insulation. In applications where vibration is likely, this can cause the material to shift, compress, or sag, compromising both the acoustical and thermal performance of the mineral wool.

A popular alternative, calcium silicate, is usually specified in high-vibration applications because of its high compressive strength and its ability to maintain its shape. The strength of calcium silicate enables it to withstand extremely demanding environments with little to no impact on the thermal performance. However, calcium silicate may not be suitable for every application because of its weight and rigidity.

The third option, thin blanket insulations, like InsulThin HT, can be ideal for applications where operating temperatures exceed 450°F and weight or rigidity can be counterproductive toward the end goal of the application. In the case of InsulThin HT, the microporous blanket is made of fumed silica particles intertwined with glass reinforcement fibers to form a composite material. The mixture of fiber and fumed silica is layered between two sections of high-temperature glass cloth and sewn together with a thread, providing a quilted product. While the fumed silica particles and glass reinforcement fibers do not oxidize within the insulation's operating temperatures, the thread may begin to degrade at temperatures starting at 600°F; however, unlike the binder in mineral wool, the threads are not a critical component of the material's structural integrity (they facilitate fabrication and installation). As a result, when temperatures reach and exceed 600°F, we can expect the material to maintain a consistent shape and consistent thermal performance.

While InsulThin HT does not offer the same NRC values as mineral wool, there is no risk of binder burnout. Additionally, this microporous blanket provides better thermal performance at elevated temperatures than many other traditional high-temperature industrial insulations (including high-temperature silica aerogel industrial insulations).

However, given that InsulThin HT is made from particles, there have been concerns that in a high-vibration environment, the material will shift and settle at the bottom of the pipe or vessel, compromising the system's thermal performance. In order to determine whether or not this is the case, Johns Manville performed a vibration test on InsulThin HT to determine how it performs in an application with constant, rigorous vibration.

While there is no specific ASTM test method to evaluate insulation settling due to vibration, we have explored InsulThin HT's ability to maintain its structural integrity, without the thread, in environments that experience excessive vibration, by modifying ASTM C411: *The Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation*.

ASTM C411 measures the sag-resistance of pipe insulation due to high temperatures and has a passing criteria threshold of $\pm 5\%$ of the original insulation thickness. We modified ASTM C411 to add an element of vibration for a duration of 100 hours. The objective of the test was to explore whether InsulThin HT experiences sagging, settling, or deformation in applications where the levels of vibration are considerable and the stitching is no longer present.

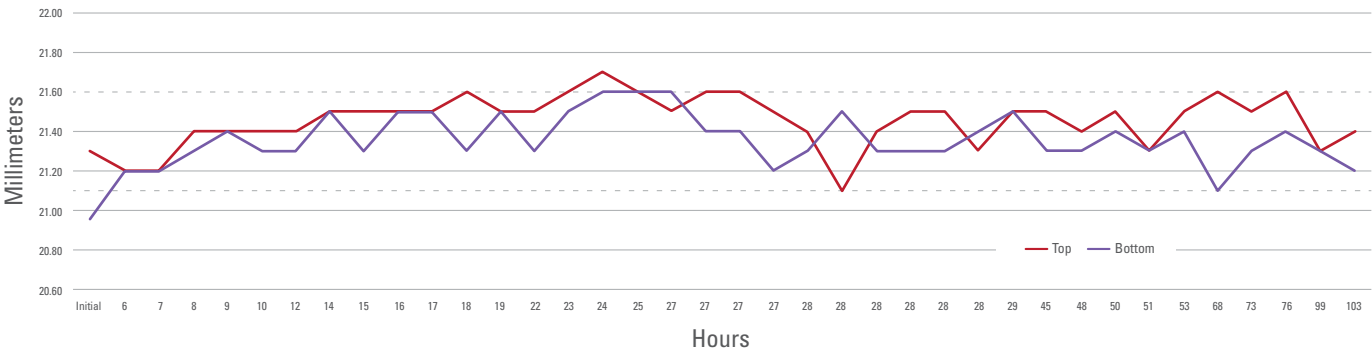
For the test, we installed two, 10mm layers of the microporous blanket on an 8" pipe section and jacketed the insulation with stucco embossed aluminum jacketing. The assembly was then conditioned (without vibration) at 600°F for 24 hours, the temperature at which the stitching begins to degrade.

At that point, the thickness of the insulation between the jacketing and the pipe was measured using calipers. Measurements were taken at the top and bottom of the assembly. The assembly was then clamped to a metal table where a vibration device was attached that would vibrate the insulation assembly for 100 hours. Throughout the test and upon its completion, the top and bottom insulation thicknesses were measured on an average of every 3 hours (36 measurements over the course of the test) to determine whether the vibration caused any settling within the assembly.

The results showed that even after 100 hours of constant vibration, the microporous product did not settle or compress. The insulation retained its shape and relatively uniform thickness despite the comparative absence of the thread used to hold the fiberglass cloth together. The insulation thickness demonstrated a $\pm 1.5\%$ deviation from the average thickness that can be attributed to measurement variability due to the vibrational component of the test. Graph 6 below shows the relatively limited variation in the material's thickness, ranging between 21.7mm (maximum thickness) and 21.1mm (minimum thickness).

If settling or sagging were to have occurred, one would have expected the top thickness to decrease and bottom thickness to increase throughout the test. In looking at the graph, this is clearly not the case.

Graph 6: Thickness Variation of InsulThin HT Throughout Vibration Testing



Graph 6: When compared to ASTM C411’s 5% deviation in thickness passing criteria, InsulThin HT comes in considerably below that at + 1.5%.

This test is an example of an environment with excessive vibration, and it represents what can be expected from InsulThin HT in a similar environment in the real world: resistance to vibration resulting in consistent thickness and thermal performance. Because of InsulThin HT’s uniform density, designers can expect its structural integrity and consistent thermal performance to remain intact in high-temperature, vibrational applications.

CHAPTER 5: DUST

When installing industrial insulation, dust is almost always a given— regardless of what type of material is being used. For this reason, most manufacturers have personal protective equipment (PPE) guidelines they recommend for installers who handle their insulation products. These guidelines usually include long sleeves, pants, safety glasses, gloves and a dust mask, and they are in place to help prevent nuisance dust from causing temporary, mechanical irritation for the installers.

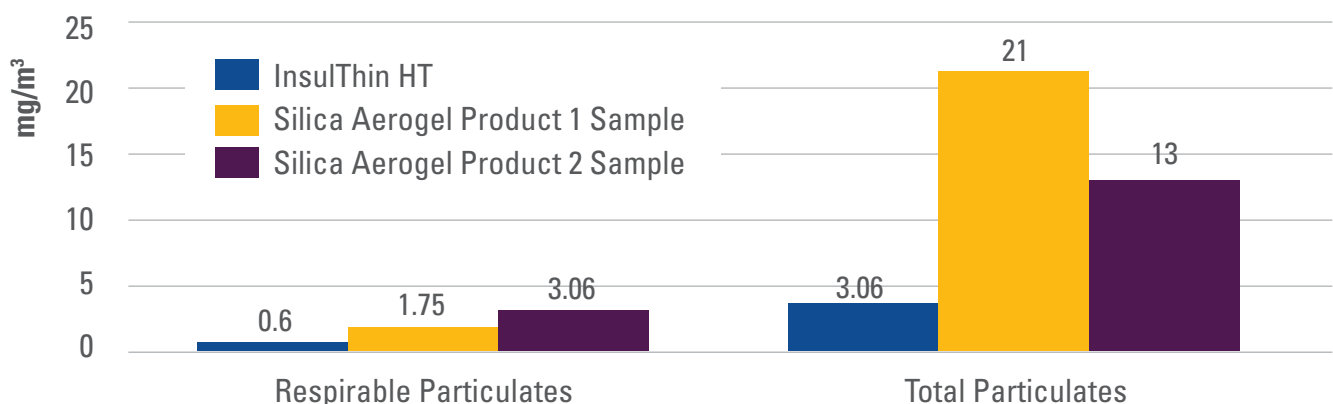
That said, some insulations can be exceptionally dusty. For example, some facility managers have implemented additional PPE requirements when installing silica aerogel insulation that include a full protective suit for the installer and/or tenting over the installation location to prevent silica aerogel dust from contaminating other areas in the facility. Naturally, this can be prohibitive to the installation process by increasing installation time, creating a challenging working environment for the installers, and increasing the overall cost of the installation.

It's important to note that the environment where the material is installed will influence the amount of dust that is present in the air. For example, an outdoor location, varied ventilation, or a substantially larger or smaller indoor location, will likely cause the levels of particulate exposure to vary. Facilities are responsible for mitigating dust exposure and adhering to OSHA standards based on their own environments, regulations, and applications.

To better understand the volume of dust produced by our competing thin, microporous, hydrophobic blanket, InsulThin HT, Johns Manville opted to run industrial hygiene sampling comparing the dust generation of an InsulThin HT sample to two different silica aerogel product samples. The testing was run indoors, in a large, well-ventilated area for 4 hours and measured the time-weighted average of respirable particulates (particles that are approximately 5 microns or less and can penetrate the gaseous exchange region of the lungs) and total particulates (airborne particles, including the respirable fraction, released by the insulation) released by the insulations during installation.

In this test, results showed that InsulThin HT produced 65%-80% less respirable and total particulates than the two silica aerogel product specimens that were tested (Graph 7).

Graph 7: Industrial Hygiene Sampling: Respirable and Total Particulates



Graph 7: Total and respirable particulates over the course of 4 hours. InsulThin HT (blue bar) generated 65-85% less dust than the two silica aerogel product specimens it was compared to.

When considering the industrial hygiene of your job site, less dusty materials like InsulThin HT can be installed with standard PPE: gloves, glasses, long sleeves, and an optional dust mask (see SDS for additional details). This can be a substantial benefit for contractors and facility owners who can avoid additional PPE accommodations to prevent exposure to excess dust.

Conclusion

Thin blanket insulations stand apart from all other industrial insulations because of their low-profile and flexibility. They have unique performance characteristics that designers, installers, and facility operators can capitalize on to design and implement thermally robust, versatile insulation systems. By understanding the nuanced components of thin blankets that we've addressed in this eBook, we can design and install more robust, resilient systems.

Well-designed systems will account for thermal performance by addressing the surface geometry of the application and the potential for thermal shift (if using silica aerogel) in the design phase. By doing so, we can help ensure that the system operates as designed. Facility owners and operators can use this very same information to trouble-shoot and retroactively correct thin blanket insulation systems that may be operating out of specification or hindering process control.

Additionally, by understanding the corrosive potential of an insulation as set forth by ASTM C1617 and as established by long-term testing, we can design assemblies that inherently have a better defense in place against corrosion under insulation. This can be an integral component to effectively battling corrosion in industrial facilities.

As a whole, thin blankets are a versatile solution to many of the challenging demands of industrial applications. As we consider the nuances and unique requirements of standard specifications, as well as the physical characteristics of thin blanket insulations, we can design, install, and utilize systems that are optimized for process control, CUI prevention, and job site handling.



**AT JOHNS MANVILLE, WE HAVE FOUR CORE VALUES:
PEOPLE, PASSION, PERFORM, AND PROTECT.**



We are committed to delivering the Johns Manville Experience through these values. As a company that manufactures building and mechanical insulation, commercial roofing materials, glass fibers, and nonwoven materials for commercial, industrial, and residential applications, we understand that we have numerous opportunities to make a positive impact in the lives of our customers and communities. It is a responsibility that we take seriously at JM, and we work diligently to make progressive contributions in terms of industry education, product performance, and social and environmental impact.

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