INSULATION FACTS #86

NAIMA
North American Insulation Manufacturers Association

Information from NAIMA:

Mineral Fiber Pipe Insulation for Chilled Water Piping

This fact sheet discusses the results of a series of tests measuring the thermal conductivity of mineral fiber pipe insulation over time when operating on below ambient temperature piping. The results of these tests demonstrate that the thermal conductivity of mineral fiber pipe insulation with a factory applied vapor retarder system does not increase significantly when the insulation system is exposed to typical temperature and humidity conditions found in chilled water applications. The tests were performed at Oklahoma State University (OSU) using the Pipe Insulation Tester (PIT) developed under ASHRAE sponsorship[1].

Introduction

Mineral fiber pipe insulation is commonly used for reducing heat gains and controlling surface condensation on chilled water piping systems in commercial buildings. When the operating temperature of the chilled water piping system is below the dew point of the surrounding ambient air, there is a potential for water vapor intrusion into the insulation system. Factory or field installed vapor retarders are utilized to minimize the rate of water vapor ingress. A continuous and effective vapor retarder system is essential as any water vapor that enters the system has the potential to condense on the cold pipe surface. If the amount of condensation is significant, the thermal conductivity of the insulation will increase.

Objective and Approach

The objective of the project was to investigate whether the thermal conductivity of a typical mineral fiber insulation system increases with time when exposed to ambient conditions commonly found in commercial buildings.

The approach was to initially test the insulation specimens in dry (i.e. non-condensing) conditions to establish a baseline thermal conductivity. These tests were run with a cold side temperature of 40°F and with an ambient dew point temperature below 36°F at all times, ensuring that there would be no condensation within the test specimens.

At the conclusion of the dry tests, the ambient temperature in the environmental chamber was set to 78°F and the relative humidity was increased to approximately 55% (ambient dew point ~60°F) and maintained for a period of 55 days. During the test the thermal conductivity was monitored to determine the thermal performance of the system over time. At the conclusion of the tests, the specimens were removed from the tester, weighed, dried, and weighed again to determine the amount of moisture accumulation within the specimens during the test.

Although the testing was scheduled for 55 days and had reached stable conditions, 1,320 operating hours is thought to be representative of the annual operation of many commercial chiller systems in North America.

Description of the Test Apparatus

The Oklahoma State University (OSU) Pipe Insulation Tester (PIT) is shown schematically in Figure 1. The tester consists of a 4' length of 3" NPS aluminum pipe located in a controlled environmental chamber. Insulation test specimens are installed on the outside of the aluminum pipe. The center 3' length of the aluminum pipe is considered

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the test section, with the two 6" sections on either end serving as transitions to the thermal guard areas. The ends of the tester are thermally insulated with cellular glass insulation (48" long x 10-½" O.D.) to minimize end effects. Centered and aligned inside the aluminum pipe is a ½" copper tube that serves as the evaporator section of a refrigeration loop. The pressure in this section is controlled to maintain a desired constant cold temperature. The annular space between the copper tube and the aluminum pipe is filled with dry sand. The thermal conductivity of the dry sand is determined during instrument calibration. During testing, the temperature drop across the sand is measured and, with the known conductivity and geometry of the sand layer, is used to determine the radial heat flux into the test section. This radial heat flux, along with the geometry of the pipe insulation specimen, is used to calculate the effective thermal conductivity of the insulation specimen. Details of the test apparatus and calibration procedures may be found in the ASHRAE Report RP-1356[2].

For the current series of tests, two nominally identical PITs were installed in the same environmental chamber. This allowed two insulation specimens to be tested simultaneously.

Figure 1. Schematic of the Pipe Insulation Tester at OSU

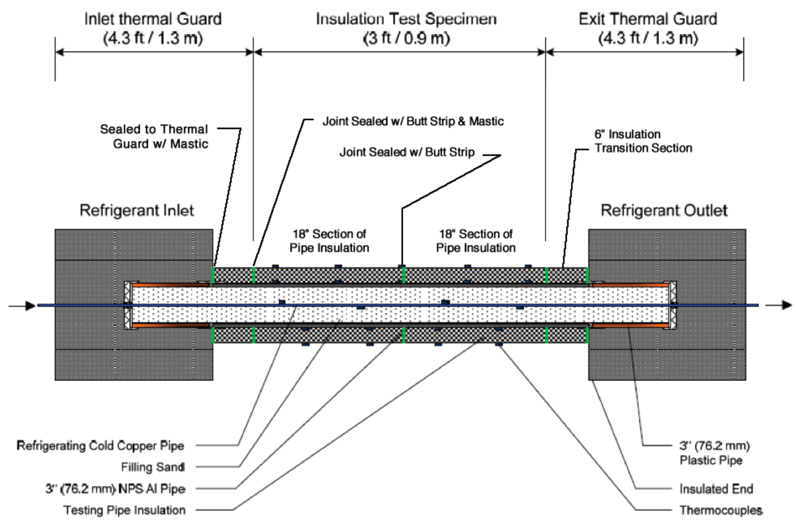
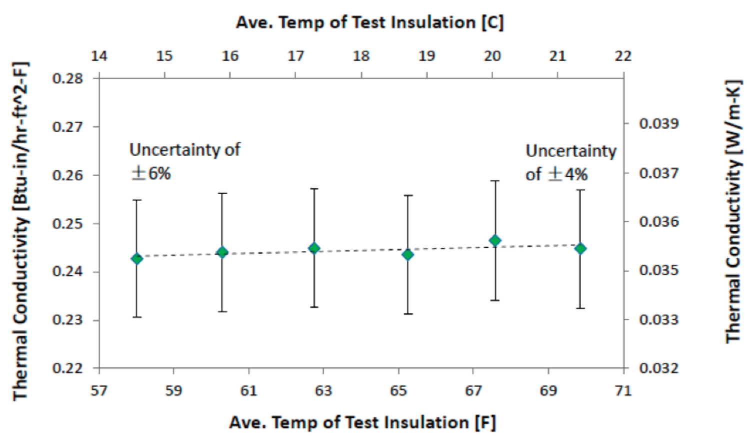


Figure 2. Pipe -Insulation Specimen Installed on a PIT. Vapor Retarder Mastic is used to seal the 6" Insulation Transition Sections to the Thermal Guard

Figure 3.1 Thermal Conductivity of Specimen 1 (Measured in Dry Conditions)



Description of the Test Specimens and Installation

The test specimens consisted of commercially available 3 x 1-½" thick sections of fiber glass pipe insulation with factory installed all service jacket (ASJ). Two 3' long sections were randomly selected from a single box of product. The test specimens were cut in half and positioned on the tester so that butt joints were located directly in the center of the test sections. The integral self-sealing lap (SSL) tape was used to seal the longitudinal lap seals on the jacket and the manufacturer's supplied butt tape strip was used to seal the butt joints. Per the manufacturer's instructions, all seals were squeegeed with a plastic card to ensure adequate adhesion. A total of four, 6" long end pieces of pipe insulation from the same lot served as transition pieces to the guard sections. These transition pieces were coated on each face with an approximately 1/8" thick layer of vapor retardant mastic to create "vapor stops" between the transition section and the test section. This was to minimize any axial moisture transport into or out

Figure 3.2 Thermal Conductivity of Specimen 2 (Measured in Dry Conditions)

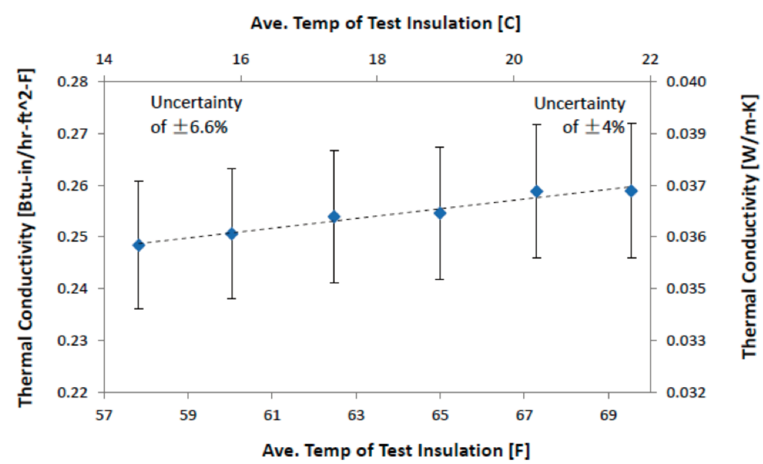


Figure 4.1 Thermal Conductivity Ratio for Specimen 1 (Measured in Wet Conditions)

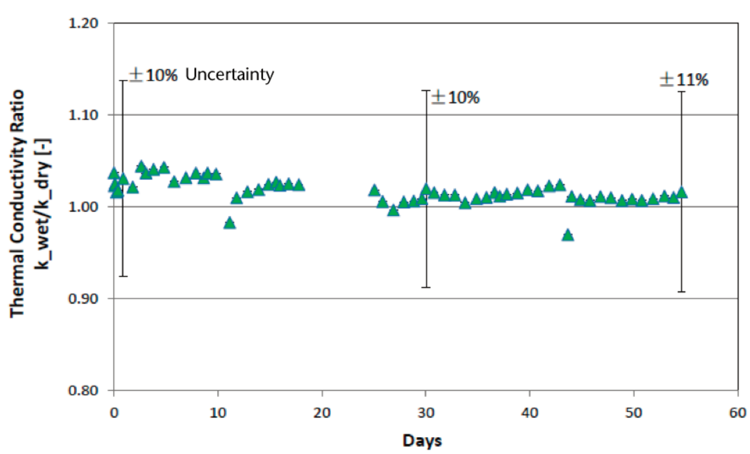
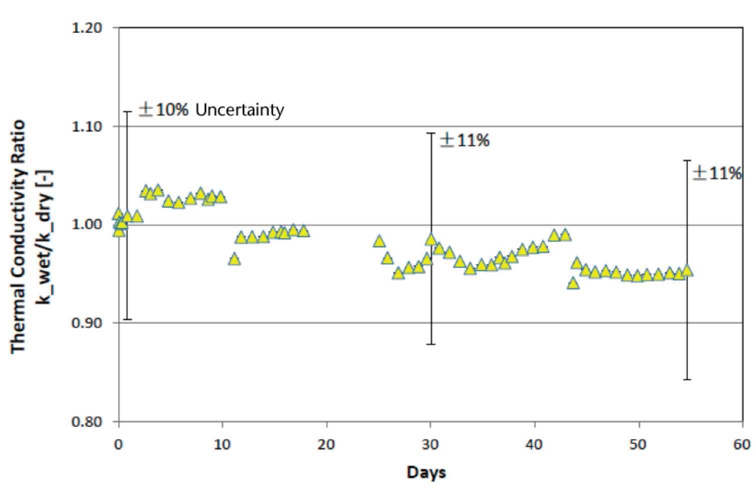


Figure 4.2 Thermal Conductivity Ratio for Specimen 2 (Measured in Wet Conditions)



of the central test section. Mastic was also applied to the bore and to the outer ASJ jacketing on the transition sections. The transition sections were intentionally excluded from the thermal and moisture content measurements. A photograph of one of the installed specimens is shown in Figure 2.

Dry Test Results

Results of the initial dry tests of the two specimens are shown in Figures 3.1 and 3.2. The measured thermal conductivity of the two specimens averaged about 0.25 Btu-in/(h· ft^2·°F) at a mean temperature of 65°F. The uncertainty of these values (shown as the error bars in Figures 3.1 and 3.2) is roughly ±5% for these test conditions.

Wet Test Results

For the wet conditions test, the insulation test specimens remained in place and the ambient room relative humidity was increased gradually (within about 12 hours) to about 55%. The results of the subsequent wet tests (ambient temperature ~ 78°F, R.H. ~ 55%) are shown in Figures 4.1 and 4.2. Here the results are shown as the thermal conductivity ratio kwet/kdry (that is the measured thermal conductivity under wet condensing conditions divided by the dry conductivity from Figures 3).

For both specimens, the measured thermal conductivity in wet conditions was within ±5% of the corresponding conductivity in dry conditions. No condensation was observed on the outer surface of the jacketing during the 55 day period of these tests.

At the conclusion of the test, the insulation specimens were removed from the testers, the ASJ jacketing removed, and the insulation specimens weighed. The specimens were then dried at a temperature of 170°F, and weighed again to estimate the quantity of water gained during the testing period. The results indicated that the specimens gained on average 0.077 lbs (~35 grams), which is approximately 0.25% by volume.

Conclusions

The results of these tests demonstrate that the thermal conductivity of mineral fiber pipe insulation with a factory applied vapor retarder system remains intact when the insulation system is exposed to typical temperature and humidity conditions found in chilled water applications. The thermal conductivity of both specimens tested in the elevated humidity conditions was within ±5% of the corresponding conductivity of the specimens tested in the dry conditions. There does not appear to be a trend indicating increasing thermal conductivity over the 55 day test. The small amount of weight gain (0.25% by volume) experienced by the specimens indicated that the vapor retarder system was effective at limiting the water vapor ingress and protecting the thermal performance of the insulation.

References

1. Cremaschi, L. et al, "Methodology to Measure Thermal Performance of Pipe Insulation at Below Ambient Temperatures". ASHRAE Research Project 1356. Dec 2011.
2. ibid

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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