WHITE PAPER

Chilled Water

Controlling condensation and moisture on below-ambient temperature piping is essential for long-term thermal performance. Selecting closed-cell elastomeric foams is one way to prevent moisture and heat gain from degrading the efficiency of a chilled water system.

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WHITE PAPER

Chilling Effect

A Better Way to Prevent Condensation on Cold Water and Refrigeration Piping

Moisture from condensation is a potential problem in any HVAC system. Cold water systems, including refrigeration lines, air conditioning lines and chilled water piping are no exception. While HVAC professionals have long applied closed-cell elastomeric foam insulation to ductwork because of its excellent moisture control properties, many are realizing its usefulness in cold water piping. Wet insulation exacerbates heat gain and therefore robs these systems of their efficiency. Because closed cell foam is impervious to moisture, it is a more sustainable and efficient insulating material.

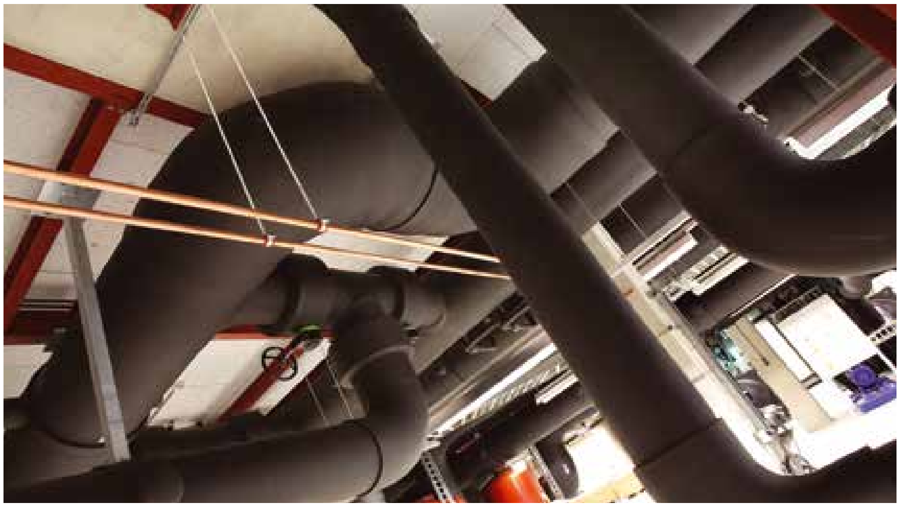
The Nature and Cause of Condensation

Water vapor is naturally attracted from warmer ambient air to cold surfaces. The water vapor in the air changes to liquid condensation at the cooler surface. Essentially, as the air cools around the cold surface, it loses its capacity to hold water in a vapor state. Water vapor changes to liquid when the temperature falls below the dew point (see Figure 1).

Figure 1

Dew point		Relative humidity at 32 °C (90 °F)
Over 26 °C	Over 80 °F	73% and higher
24–26 °C	75–80 °F	62–72%
21–24 °C	70–74 °F	52–61%
18–21 °C	65–69 °F	44–51%
16–18 °C	60–64 °F	37–43%
13–16 °C	55–59 °F	31–36%
10–12 °C	50–54 °F	26–30%
Under 10 °C	Under 50 °F	25% and lower

The same physics applies to cold water piping. If the temperature surrounding the piping drops below the dew point, condensation will form on the pipes. The presence of moisture not only actually robs the system of its thermal efficiency, it provides suitable conditions for mold and mildew. Without adequate insulation or the right insulation, the system will achieve equilibrium on the pipe surface … resulting in condensation on the pipe.



Why Moisture Control is Critical to Efficiency

If moisture intrudes the insulating material surrounding cold water piping, efficiency is lost. As explained below, this can happen especially with open cell insulations when their separate vapor retarders are damaged or otherwise compromised. For every 1% moisture gain, there is a 7.5% loss in thermal efficiency. In other words, a single percent increase in moisture equates to a 7.5% increase in thermal conductivity (thermal k) — or the transference of heat from one surface to another — a condition that one wants to avoid in chilled water systems, as it leads to energy loss and higher operating cost. Figure 2 shows the effect of water vapor intrusion on Thermal k.

Figure 2 - Effect of Water Vapor Intrusion on Thermal K

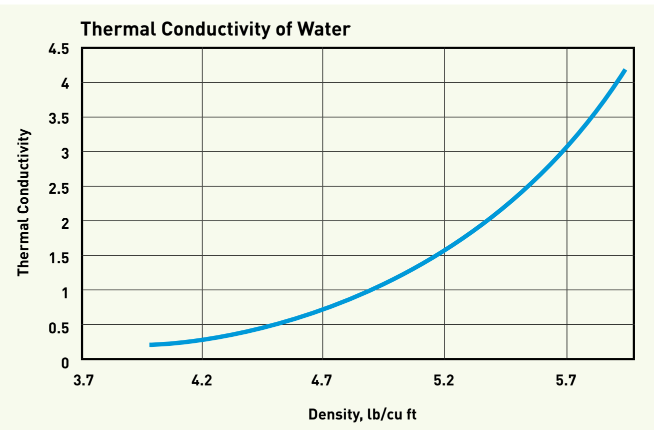


Figure 2: Every 1% by volume increase in moisture (density) of the insulation yields a 7.5% increase in thermal conductivity. Thermal conductivity of Water equals 4, the point of total saturation of the Insulation material. When the vapor jacket of open cell insulation is damaged, the insulation can relatively quickly reach saturation due to wicking... and result in very high thermal k values.

To better understand thermal conductivity, consider the comparative thermal conductivities of the following:

Figure 3

Air	0.15 to 0.18 BTU – in/hour sq ft F
Insulation	0.25 to 0.30 BTU – in/hour sq ft F
Water	4.1 BTU – in/hour sq ft F
Ice	15.5 BTU - in/hr sq ft F

The impact of moisture on thermal performance is obvious when comparing the thermal conductivity of water to insulation. The thermal conductivity of water is approximately 13 times greater than insulation, therefore heat transfer from the air to the chilled water pipes greatly increases when insulation gets wet. And heat gain of the chilled water pipes equates to loss of costly cooling BTUs. The cooling system will work harder to compensate for the loss in efficiency and possibly reduce the service life of the system.

Vapor Retarders: Durability Counts

Whether water vapor intrudes the insulation material and how quickly it does so, depends primarily on the insulation's water vapor retarder and the material's wicking properties. Some insulations, those with open cell structures like fiberglass, require a separate vapor retarder or jacket applied to the outer surface. In some cases, these are made of organic cellulose which can actually serve as a food source for mold if other key conditions (moisture and temperature) are suitable for mold spores to grow.

Since these separate retarders are vulnerable to damage, extreme care must be taken when handling and installing them. A single break in the retarder can eventually result in moisture wicking throughout the open cell material, rendering it ineffective and compromising the integrity of the entire insulation system.

Unlike open cell insulations with separate vapor retarders, closed-cell elastomeric foams like ArmaFlex® have the vapor retarder built-in. The closed-cell structure prevents the transference of moisture and the multi-layered structure of closed-wall cells can't be compromised by surface punctures or tears. Wicking cannot occur in closed cell insulations.

While installers must be vigilant in the effort to install open cell insulations that require separate vapor jackets, this is a non-issue with closed-cell material. This is a major advantage during installation, since this is the time when vapor jackets are most often damaged.

Why Closed-Cell Structure Offers Superior Protection Against Condensation

The fact that closed-cell structures are inherently durable and virtually impermeable to water means better lifetime efficiency. This is recognized in ASHRAE Fundamentals 2017 which suggests that cold systems be protected through the use of very low permeance insulating material with a water vapor transmission rate (WVT) of 0.10 per inches or less. (ArmaFlex has a very low WVT of only 0.05). Permeability is defined as the amount of water vapor that passes through a unit thickness of material (typically one inch) over a given period of time under standard pressure. Figure 4 shows the Water Vapor Permeability of various types of insulation materials:

Figure 4

Material	Permeability
Still air (reference point)	120
Fiberglass	25-125
Phenolic Foam	26
Polystyrene (bead)	2.6
Polyurethane foam	1.3 – 4
Polyisocyanurate foam	0.9 – 2.7
Polystyrene extruded	0.4 (w/skin)
ArmaFlex elastomeric foam	0.05

Closed-cell elastomeric foam, specifically ArmaFlex, has a very low permeability rating, and therefore delivers consistent, long-term performance.

That's not to say that all elastomeric foams are equal in performance. Today, commercially available elastomeric in the US have thermal conductivities at 75ºF mean temperature of 0.25 to 0.38 Btu-in/hr-ft2-ºF and water vapor permeabilities of 0.05 to 0.65 perm-inches. Accordingly, the long-term and short-term performances of these materials vary greatly.

Conclusion

Controlling condensation and moisture on cold water lines is essential for long term thermal performance. While condensation and moisture are known as culprits in mold growth, they also have a significant impact on system efficiency, as moisture degrades the performance of the insulating material. Selecting closed-cell elastomeric foams is one sure way to prevent moisture (and therefore heat gain) from invading the piping system. Not only does closed-cell material possess a low permeability rating, it is much less vulnerable to punctures and tears that can render other forms of insulation, specifically open cell materials, ineffective. ■

Glossary for Cold Systems

Thermal Conductivity – The amount of heat (BTU) transferred in one hour through one square foot of a homogeneous material 1-inch thick for a difference in temperature of 1 degree F. The lower the value, the better the insulator.

Perm – A measure of vapor-transmission rate. Defined as 1 grain of water vapor per hour for 1 square foot area for 1 inch of mercury-pressure difference. The lower the value, the better the vapor retarder.

Permeability – A rating of a material giving the amount of water vapor that passes through 1 inch thickness of the material.

Dew Point – The temperature to which air must be cooled to become saturated with water vapor (100% relative humidity). When cooled more, the airborne water vapor will condense to form liquid water (condensation).

Relative Humidity – A measure of the amount of water in the air compared with the maximum amount of water the air can hold at the current temperature.

All data and technical information are based on results achieved under the specific conditions defined according to the testing standards referenced. It is the customer's responsibility to verify if the product is suitable for the intended application. The responsibility for professional and correct installation and compliance with relevant building regulations lies with the customer. Armacell takes every precaution to ensure the accuracy of the data provided in this document and all statements, technical information and recommendations contained within are believed to be correct at the time of publication. By ordering/receiving product you accept the **Armacell General Terms and Conditions of Sale** applicable in the region. Please request a copy if you have not received these.

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As the inventors of flexible foam for equipment insulation and a leading provider of engineered foams, Armacell develops innovative and safe thermal, acoustic and mechanical solutions that create sustainable value for its customers. Armacell's products significantly contribute to global energy efficiency making a difference around the world every day. With 3,100 employees and 24 production plants in 16 countries, the company operates two main businesses, Advanced Insulation and Engineered Foams. Armacell focuses on insulation materials for technical equipment, high-performance foams for high-tech and lightweight applications and next generation aerogel blanket technology.

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