Protecting K-Flex Elastomeric Insulation from Exposure to Outdoor Elements

Thermal insulation is often installed outdoors in a variety of operating applications, exposing it to the widely variable elements of nature. While the type of protection depends on the application and its surrounding environment, protective coatings or jacketing help prevent system deterioration, which can occur when unprotected elastomeric insulation (NBR/PVC or EPDM based) is exposed to outdoor elements.

Factors Associated with Outdoor Exposure

The factors that contribute to the degradation of thermal insulation when exposed to outdoor elements are documented in the ASHRAE Handbook of Fundamentals. Factors include, but are not limited to:

- Mechanical abuse (personnel walking on the insulation, tools being dropped or placed on the material, wind-driven sand)
- Animal abuse (birds and other vermin)
- Moisture (rain, snow and sleet)
- UV degradation / solar radiation
- Wind
- Atmospheric contamination
- Chemical attack from industrial environments
- Expansion and contraction of the insulation due to temperature fluctuations

Mechanical abuse can result in torn insulation. Birds have been known to remove sections of unprotected insulation, creating gaps in the insulation. All insulation (open or closed cell) is subject to absorbing moisture from the elements when exposed to moisture or high humidity over long periods of time. Contamination from the atmosphere; i.e. a paper or coal-fired plant nearby; or installation in industrial applications can cause damage from chemical attack or deposit organic contaminants on the insulation resulting in mold growth. These factors contribute to moisture pick-up by the insulation. Gaps in the insulation seams, butt joints or missing insulation will also result in failure of the insulation system.

End Result of Thermal Insulation Exposed to Outdoor Elements

Premature failure of insulation due to degradation from outdoor elements can result in safety or process failures, and also has economic consequences. The primary reasons for insulating a cold line are to prevent heat gain, which leads to energy and operating cost savings, and to prevent condensation (moisture accumulation on the surface and possible moisture absorption) on the insulation.

The effects of moisture absorption on thermal insulation are well documented. For every 1% moisture gain, there is a 7.5% increase in thermal conductivity (thermal k) or the resultant heat gain or loss from one surface to another. As the insulation's k-value degrades from the pick-up of moisture, it creates a scenario

for greater condensation and a cycle for complete failure. The presence of moisture not only degrades the thermal performance of the insulation (resulting in economic loss and potentially process failure), it also creates an environment that contributes to CUI (corrosion under insulation) of the pipe itself. Even insulations with low water vapor permeability (less than .1 perm – inch) will absorb moisture over a long period of time when exposed to high humidity or long periods of moisture (rain, sleet or snow), or high vapor drives (e.g. very cold process in a high temperature and high humidity environment) if not protected. An example of this type of protection would be installing an appropriate vapor retarder and weathering jacket or coating.

Gaps in the insulation can be caused by mechanical abuse, damage from birds, thermal contraction and UV degradation. The effects of gaps in the insulation (open seams or missing sections of insulation) often go unrecognized for the effects they can have on a below ambient operating system. On a hot system, it is easy to recognize and calculate the efficiency loss as a result of the uninsulated pipe area. Because the surface area of the uninsulated pipe may not be great, the losses may not be of a great concern. But on a cold operating system, even a small gap will result in a massive failure. The gap will create a situation where moisture from daily condensation formation or rain will travel down the pipe under the insulation and accumulate at the lowest point, resulting in waterlogged insulation and a complete failure of the operating system.

The Solution

Use of a protective coating /mastic or covering will go a long way towards providing a system that will not fail. Using a closed-cell foam product with a low permeability factor (less than 0.05 perm – inch) will minimize moisture pick up if there is a minor failure in the protective coating /mastic or covering. The protective coating /mastic or covering will ideally not just protect the insulation from UV degradation, but will also protect it from all the other factors associated with an outdoor application. ASTM C 1710: "Standard Guide for Installing Flexible Closed-Cell Foam Insulation" recommends the use of a protective coating / mastic or covering for outdoor applications.

Types of Protective Coatings / Mastics and Coverings

There are many types of protective coatings/mastics and coverings on the market. Selection of the proper one will depend on the application, the environment in which it is operating, the expectation of the owner / operator and the type of insulation being installed.

Mild Service / Low Expectation: Insulating the refrigerant lines from a heat pump into a residence would be considered mild service. This is because it is usually covered by bushes, is somewhat protected and has a low expectation of service. Failure of this type of insulation will not cause a catastrophic failure and the owner does not expect the installation to last for more than a few years. In this application, there may be no need for any protective coating / covering if a flexible, closed-cell foam insulation is used except as where required by code. If one were required or desired, a water-based coating would suffice.

Severe Service / High Expectation: Insulating a cold process line or a chilled water / refrigerant line on a rooftop in Florida or Texas would be considered severe service with a high expectation of performance. Failure of the insulation would result in a failure of the application, while performance expectation is typically10 plus years of service with few or no maintenance issues. A failure of the system may even shut the operation down at great expense. In this case, closed-cell foam with a 0.0 perm-inch, high-performance vapor retarder jacket should be used.

In addition to the severity of the service and the performance expectation, the type / shape of the item being insulated will have a factor in selecting the correct insulation protection.

Coatings: Coatings offer the lowest initial cost with minimal protection, offering UV protection, but no protection from mechanical abuse or water vapor permeability. They also require annual maintenance. Coatings are offered in both water-based (latex) and solvent-based versions. These are usually recommended for mild service and low expectations.

Mastics: There are various types of mastics that are typically installed in conjunction with fiberglass mesh or canvas. Some offer only UV protection, while others also offer water vapor permeability and mechanical abuse protection. Mastics require multiple coats and periodic maintenance.

Polymeric (plastic), Metal Foil or Composite Products: This type of material offers the widest range of jacketing products and is growing. This product group offers the advantages of cost, ease of use, weight and possibly reliability. They include various polymer materials such as PVC, PVDC or Polyisobutylene combined with fiberglass mesh and or metal foils. They have the added advantage of being flexible and easier to install (no special tools required) than metal jacketing. Flexible jackets over flexible insulation allow the insulation system to "recover" from most types of impact with minimal aesthetic damage. PVC jacketing is not recommended for outdoor applications unless it is protected by a UV barrier film.

Metal Jacketing: Metal jacketing includes smooth or embossed aluminum, stainless steel, galvanized steel and variations of those mentioned with different coatings or paints. Metal jackets have traditionally been considered the best outdoor option. In addition to offering abuse / UV protection and moisture vapor permeability, some also offer a degree of fire protection, i.e. stainless steel. Rigid jackets are not ideal for installation over flexible elastomeric insulation due to difficulty in banding properly and due to potential indentation damage as the low compression resistance of elastomeric insulations do not provide significant support to the metal jacketing. Note that metal jacketing is *not* a vapor barrier. Even if all seams and joints are sealed initially, movement of the jacket due to thermal expansion and contraction will quickly break these seals. Metal jacketing is often supplied with an inner layer to provide slip and protect the insulation. Paper liner should not be used. Polysurlyn liner (typically blue or purple) is recommended.

Note: Jacketing selection will affect the insulation thickness requirement depending on the ambient conditions, system operating temperature(s) and the emissivity of the jacketing. Jacketing with high emissivity (0.8 – 0.9) will require less insulation on a cold system than a low (0.04) emissivity jacket. These differences can be calculated using K-Flex USA's IsoCalc or NIA's 3E Plus software. Both are available for free download.

Fitness for Use and Workmanship

A key point to remember is that no matter what type of protection is used for the insulation, workmanship and knowledge are keys to a successful installation. The material selected must be reviewed for fitness of use with the application (severity of service and performance expectation) and it must be installed properly. Special attention must be given to vapor stops, vapor barriers and the tie-ins between the two on cold piping systems. Vapor stops must be able to withstand dynamic movement, exposure to the elements (at terminations) and possible undercutting corrosion.

In addition, regular inspection and repair must be conducted to maintain the integrity of the system. It is important to consider maintenance and total life cycle costs in addition to upfront expenses. An example of this may be the recommendation to use a polymeric covering rather than a coating or mastic, which would provide lower initial cost, but may require more frequent (and costly) maintenance.

Options Being Recommended in the Marketplace; Buyer Beware

There are many insulation, protective coating / mastics and jacketing options being recommended in the marketplace for various applications. In some cases, several options could be used successfully in the same application. The key is to balance performance and expectation with cost. Using a closed-cell foam material in a system operating at below-ambient temperatures, particularly in an outdoor application is a necessity to reduce issues with moisture intrusion. In most cases, except in mild service and limited performance expectation, some type of coating, mastic or jacket protection is required. Some insulation manufacturers may claim superior UV resistance, suggesting that no additional protection is needed for outdoor service even in severe service with high performance expectations. These claims should be substantiated for actual length of extended service offered. For example, if the life expectancy of a standard product is 1 year and the expectation of performance is 10 years, clearly one would conclude that it should be protected. If the improved product had a life expectancy of 1 ½ years, one would still conclude that protection is needed even though it offers slightly better properties. One also has to remember that UV resistance is only one of many issues associated with outdoor applications. If the product does not protect against all of them, it will not meet the established performance criteria.

Unfortunately, it is difficult to determine the exact outdoor service life of a product application due to the wide range of environmental conditions that may be encountered. Accelerated UV aging studies only examine one portion of the issues faced and it is difficult to correlate UV test results to actual outdoor exposure because of the wide range of potential exposures in different parts of the country. There is no industry accepted criteria to determine acceptable performance. Recommendations are usually based on actual field history and experiences. Guarantees are usually very limited and protect the manufacturer more than the end user.

Conclusion

Upfront knowledge and communication between all parties are the keys to a successful outdoor system operating at below-ambient temperatures. This includes reviewing the following with the insulation contractor: performance criteria and expectations, environmental conditions the application will be operating in, material options and installation recommendations from the manufacturer, and best practices from various industry sources. Good communication between the owner / operator, the engineering firm, the insulation manufacturer and the insulation contractor is absolutely necessary.

K-Flex USA is a leading manufacturer of flexible, elastomeric closed-cell foam insulation used in below-ambient systems. K-Flex offers a range of complete insulation systems (thermal insulation, fittings, protective coatings, jacket systems and adhesives) for insulating below-ambient systems installed outdoors. These systems include factory or field applied polymeric jacketing that can be 100% adhered to the insulation providing a 0.0 perm – inch system, or which can be applied unadhered to allow for the different rates of movement between the insulation, vapor barrier and jacket (recommended for systems operating below 0°F). The polymer jacketing types are specific to the application, but all offer a flexible system with watertight seams. Available factory-built fittings insure a correct fit on all fittings. Eliminating field installation steps speeds up the installation, while making the application more reliable. The flexible foam product also allows for field adjustments in the installation if necessary.

For systems operating at below-ambient temperatures in an outdoor environment, K- Flex USA recommends K-Flex Clad® AL (PVC/aluminum film composite) or Clad® WT (PVC/ mylar white) products for commercial and light industrial applications, and K-Flex Clad® IN (polymeric sheeting) for heavy industrial or marine / oil and gas applications. These systems provide 10+ years of service in most applications with little or no maintenance.