Ammonia

Product performance for insulation of ammonia piping
ABOUT K-FLEX USA

K-FLEX USA IS A LEADING MANUFACTURER of flexible, closed cell elastomeric insulation for mechanical piping, air handling units and vessels.

Designed for ease of installation and reliable performance, K-FLEX USA products provide excellent thermal and acoustical properties, including mold resistance (GREENGUARD® certified) and energy conservation.

K-FLEX USA prides itself on being responsive to the market, providing dependable service to customers throughout North America, bringing an innovative approach to product offerings, and having products that are 3rd party certified.

K-FLEX USA PRODUCTS HAVE DELIVERED EXCELLENT PERFORMANCE in many applications, including: HVAC/R, Commercial/Industrial, Oil & Gas, Plumbing, Marine, Solar, and OEM Equipment/Applications.

AS A MEMBER OF THE IK INSULATION GROUP, K-FLEX USA has global access to strong fundamental research programs and state-of-the-art levels of technical knowledge and customer support specifically related to thermal and acoustical elastomeric insulation.

COMPANY HISTORY

1965 Rubatex was formed.
1975 Halstead was formed and INSUL-TUBE® became a well-known product brand.
1975 INSUL-TUBE® became a well-known product brand.
1989 L’Isolante K-FLEX was formed.
1999 Rubatex acquires Halstead to form RBX Industries.
2002 NKF enters into a Sales and Marketing Agreement with RBX Industries.
2004 NKF acquires RBX’s mechanical insulation business.
2008 Jan. 10, 2008 L’Isolante K-FLEX redeems Nomaco shares in NKF and goes to market as K-FLEX USA.

K-FLEX USA BENEFITS
• Designed for lasting performance: K-Value: 0.245 at 75°F & WVT: 0.03 perm-in
• Responsive to market
• Industry & Product expertise
• 3rd Party Certified Products
• Broad size range: 25/50-rated up to 2” thick
• Systems Approach
• Factory-applied PSA & Cladding
• Full line of accessories

GLOBAL PRESENCE
L’ISOLANTE K-FLEX:
• 14 production facilities worldwide
• Commercial distribution in 43 countries
• Headquartered in Italy
INSULATION SELECTION

Critical Factors to Consider

- Proper Material Selection, Thickness, Installation & Maintenance =
  - Energy Savings
  - Eliminate Refrigerant (i.e. Ammonia) Leakage
  - Condensation Control
  - Moisture Intrusion & Ice Formation Prevention
  - Improved Equipment Performance
  - Minimize Corrosion
  - Mold / Mildew Resistance
  - Personnel Safety
  - Process Control
  - Meets Fire Codes
- Cost efficiency
  - Cost to remove a failed system = 3-5 times initial cost of installation + additional costs of downtime & mold removal.

Application Considerations

- Extreme below-ambient conditions (-50°F to 40°F process) --> vapor drive.
  - High level of moisture vapor pressure in ambient air trying to get to air surrounding the insulated pipe surface where moisture vapor pressure is much lower.
- Unidirectional --> steadily drives against insulation.
- Magnified when the system operates continuously in cold mode and in high humidity conditions.

Causes of Insulation Failure

Next to the issue of open seams, moisture vapor intrusion is the single-most destructive factor to insulation, with studies showing that for every 1% moisture gain, the insulation efficiency drops 7.5%. This gain takes place as moisture-laden air migrates through the insulation system to the pipe surface and forms moisture on the pipe. The closed cell structure of the insulation is critical as moisture inevitably accumulates in permeable insulation even with a concentrated vapor retarder jacket. The presence of job site abuse and improper installation means there is additional risk involved with permeable insulation products, which rely on jacketing to serve as a vapor retarder. Wet insulation and mold growth on the outer surface of the system (pictured right) are indicators that the insulation has failed.
INSULATION OPTIONS

The purpose of these technical notes is to offer designers and those working in the field a thorough overview of insulation materials commonly used for the purpose of insulating ammonia systems. For an understanding of the analysis carried out, we will refer both to the most commonly used materials for ammonia applications (table 1) and to the key properties of the different insulation options in table 2.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>K-FLEX CLOSED CELL ELASTOMERIC FOAM</th>
<th>CELLULAR GLASS</th>
<th>POLYSTYRENE</th>
<th>POLYISOCYANURATE (PIR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>K-FLEX CLOSED CELL ELASTOMERIC FOAM</td>
<td>0.245</td>
<td>0.31</td>
<td>0.24</td>
</tr>
<tr>
<td>B</td>
<td>CELLULAR GLASS</td>
<td>0.03</td>
<td>0.001</td>
<td>1.5</td>
</tr>
<tr>
<td>C</td>
<td>POLYSTYRENE</td>
<td>0.03</td>
<td>0.001</td>
<td>1.5</td>
</tr>
<tr>
<td>D</td>
<td>POLYISOCYANURATE (PIR)</td>
<td>0.03</td>
<td>0.001</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Table 2

TECHNICAL PROPERTIES

<table>
<thead>
<tr>
<th></th>
<th>K-FLEX Closed Cell Elastomeric</th>
<th>Cellular Glass</th>
<th>Polystyrene</th>
<th>Polyisocyanurate (PIR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal k (75°F mean)</td>
<td>0.245</td>
<td>0.31</td>
<td>0.24</td>
<td>0.19</td>
</tr>
<tr>
<td>water vapor transmission (wvt) without jacketing (perm-in)</td>
<td>0.03</td>
<td>0.001</td>
<td>1.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Service Temperature (°F)</td>
<td>-297°F to +220°F</td>
<td>-450°F to +800°F</td>
<td>-65°F to +165°F</td>
<td>-297°F to +300°F</td>
</tr>
<tr>
<td>Density (pcf)</td>
<td>3 - 4</td>
<td>8.0</td>
<td>0.7 - 3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Closed Cell Structure</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>90%</td>
</tr>
<tr>
<td>Flexible</td>
<td>Yes</td>
<td>No (Fragile)</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Requires Jacketing</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>ASTM E 84 flame rating (2”)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Self-seal closure option</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Thermoplastic (Highly combustible, may melt, drip or carry a progressive flame)</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
WATER VAPOR TRANSMISSION (WVT)

As indicated by the detrimental effects of water vapor intrusion, the water vapor transmission (wvt) of an insulation material is a critical component of its performance. If the insulation material is vapor permeable, as indicated by a high wvt value, moisture can move through the insulation to reach areas where the temperature is low enough to form condensation, even if the surface temperature of the insulation is high enough to prevent surface condensation. An insulation material with low wvt would prevent this situation from occurring.

The chart below shows the wvt values for commonly used insulation materials in ammonia applications. As the chart indicates, elastomeric and cellular glass are the only two unjacketed materials that are classified as Class 1 vapor retarders as defined by ASHRAE.

**wvt Comparison**

<table>
<thead>
<tr>
<th>Insulation Material</th>
<th>WVT (perm-in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular Glass</td>
<td>0.001</td>
</tr>
<tr>
<td>Polysocyanurate (PIR)</td>
<td>4.0</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>1.5</td>
</tr>
<tr>
<td>K-FLEX Elastomeric</td>
<td>0.03</td>
</tr>
</tbody>
</table>

* Taken from manufacturer’s published data.

ASHRAE vapor retarder classes
Class 1: 0.1 perm or less
Class 2: 0.1 – 1.0 perm or less
Class 3: 1.0 – 10 perm or less
WATER VAPOR TRANSMISSION (WVT)

A further analysis of the importance of an insulation material's wvt is illustrated below.

K-FLEX insulation’s closed cell structure and low wvt inherently resists moisture, providing distributed resistance against moisture vapor intrusion without the need of a jacket.

Additionally, elastomeric closed cell insulation materials have an established history of successful use as an insulation material for cryogenic applications (see Project Experience on page 11).

In contrast, closed cell materials with a high wvt (i.e. polystyrene and polyisocyanurate) are not inherently resistant to moisture and rely on a concentrated moisture vapor barrier (jacket) for protection against moisture intrusion.

If the barrier is damaged (even a pinhole) or the edges are not properly sealed, they are susceptible to moisture intrusion and subsequent energy loss or mold growth. Once moisture penetrates, it can wick and involve large areas in the mold growth and energy loss process.

wvt Performance Comparison

- High wvt: requires concentrated Vapor Retarder Jacket
- Low wvt (K-FLEX .03 perm-in): Inherent Vapor Retarder: Distributed Resistance

Condensation formation resulting in moisture build-up

Warm Air

Cold Line
MOISTURE GAIN & THERMAL $k$

**Thermal $k$ performance over time with moisture gain (10 years)**

The effect of moisture gain on thermal $k$ after 10 years is shown below. The data leads to the conclusion that on most below-ambient systems, if the wvt of the insulation is less than 0.10 perm-in, there will be minimal long-term effects on the $k$-value.

<table>
<thead>
<tr>
<th>wvt (perm-in)</th>
<th>.01</th>
<th>.10</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>k-value (start)</td>
<td>.250</td>
<td>.250</td>
<td>.250</td>
</tr>
<tr>
<td>k-value (10 years)</td>
<td>.255</td>
<td>.310</td>
<td>1.88</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material Type</th>
<th>k-value (75°F mean)</th>
<th>wvt (perm-in) unjacketed</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-FLEX Elastomeric</td>
<td>0.245</td>
<td>0.03</td>
</tr>
<tr>
<td>Cellular Glass</td>
<td>0.31</td>
<td>0.001</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>0.24</td>
<td>1.5</td>
</tr>
<tr>
<td>Polysocyanurate (PIR)</td>
<td>0.19</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Effect of seams on risk of moisture intrusion

Seams in an insulation system often have a much higher wvt than the insulation itself. This can have a significant impact on the moisture absorbed by the system.

Also, insulations that rely on a concentrated vapor barrier often get damaged, resulting in a much higher wvt than reported in the literature. Many insulation material types, such as cellular glass or polystyrene which are fabricated in two halves, require double the number of seams as K-FLEX, thus increasing the risk for moisture intrusion.

Further, K-FLEX is also available in 6’ lengths (compared to 3’ or 4’ lengths), significantly reducing the number of butt joints that need to be sealed in a system.

Conditions: Ambient 90°F • Pipe 40°F • Relative Humidity 85% • Pipe Size 4” • Insulation Thickness 2” • wvt drive exists 50% of the year
K-FLEX USA: PERFORMANCE ADVANTAGES

Analysis of main features

- Low wvt without jacketing (0.03 perm-in, Class 1 vapor retarder).
- No jacket required for indoor applications.
- Performance against damaging moisture intrusion guaranteed for a minimum of 10 years from date of installation.
- Excellent thermal k (0.245).
- CUI resistance: moisture migration prevention, especially important with iron pipe.
- Does not fracture from pipe vibration or expansion/contraction cycles.
- Low VOC emission, CFC- and HCFC-free.
- High mold & mildew resistance.
- Meets Fire Safety Codes (25/50-rated up to 2” wall).
- Single material can be used on lines that cycle hot to cold due to wide temperature range (vs. i.e. polystyrene temperature limitations).
- IIAR Handbook: “The insulation itself should be a low thermal conductivity material with low water vapor permeability and it should provide moisture resistance.”
- When the cause-effect relationship of all of these factors are considered, K-FLEX outperforms competitive materials.

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>RATING</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temperature Range (°F)</td>
<td>-297°F to +220°F</td>
<td>ASTME 96</td>
</tr>
<tr>
<td>wvt</td>
<td>0.03 perm-in</td>
<td>ASTM C 209</td>
</tr>
<tr>
<td>Water Absorption % (volume change)</td>
<td>0</td>
<td>ASTM C 177 &amp; C 518</td>
</tr>
<tr>
<td>Thermal k (75 °F mean)</td>
<td>0.245 (Btu-in/h-ft²°F)</td>
<td></td>
</tr>
<tr>
<td>Fire Rating</td>
<td>25/50 up to 2” thick</td>
<td>ASTM E 84, NFPA 90 A / 90 B</td>
</tr>
<tr>
<td>Density</td>
<td>3 - 4 pcf</td>
<td>ASTM D 1622</td>
</tr>
<tr>
<td>Mold Resistance</td>
<td>Pass</td>
<td>UL 181</td>
</tr>
<tr>
<td>Energy Rating</td>
<td>Complies</td>
<td>ASHRAE 90.1 &amp; 189.1</td>
</tr>
<tr>
<td>UV Weather Resistance</td>
<td>Pass</td>
<td>QUV Chamber Test</td>
</tr>
</tbody>
</table>

K-FLEX® LS Sheet

K-FLEX® LS Tube
K-FLEX USA: INSTALLATION ADVANTAGES

Analysis of main features

• No jacket for indoor applications.
• Flexible: non-breakable, easily conforms to curvatures.
• Lightweight: easy handling.
• Low maintenance & easy to clean.
• Less prone to damage from shipping, installation errors & job site abuse.
• 6’ lengths for fewer joints/seams (vs. 3 or 4 ft lengths).
• Safe to handle: Non-abrasive, No protective clothing required.
• Faster installation: reduced steps on-site
  • No metal bands or on-site application of complex vapor retarder jackets
  • Non-dusting = reduced time spent vacuuming & screening work areas
  • No fabrication from bun form to tubing or sheet necessary

Indoor: 2” and below

• Single Layer – K-FLEX® LS: No jacket
• 6 foot lengths

Outdoor: 2” and below

• Single Layer – K-FLEX Clad®: 1-Step / No through seam

Competitive: 2” and below

• Single Layer – Competitive: Multiple Steps
• 3 or 4 foot lengths
K-FLEX USA: INSTALLATION ADVANTAGES

Multiple layers: 2” and above

- Multiple Layers – Competitor and K-FLEX USA

K-FLEX USA: SERVICE ADVANTAGES

- Responsive to market, world leader.
- Product & Industry expertise:
  - NIA Certified Insulation Appraiser on staff.
  - ISOCALC: calculator used to determine thickness to prevent surface condensation.
- 3rd Party Certified Products.
- Broad size range – tubes & sheets.
- Systems Approach:
  - Factory-applied solutions.
  - Full line of accessories.

COSTS: MATERIAL & LABOR

<table>
<thead>
<tr>
<th>Material</th>
<th>Material Cost ($)</th>
<th>Labor Cost ($)</th>
<th>Total Installed Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5” Elastomeric</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
</tr>
<tr>
<td>1.5” Cellular Glass w/ ASJ</td>
<td>5% more</td>
<td>30% more</td>
<td>20% more</td>
</tr>
</tbody>
</table>

*Material, Labor and Total Installed Cost ($) values obtained from 2011 RS Means Mechanical Cost Data. Cost data not available for polystyrene or polyisocyanurate. Elastomeric material, labor, and total installed costs for 1.5” based on extrapolation from known RS Means costs for 1” elastomeric / cellular glass. Detailed analysis available upon request.*
CRYOGENIC PROJECTS EXPERIENCE

ECOREL, ITALY: BOG (boil off gas) Compressor

AGIP / BIS, Norway: Offshore Barge

CRYOSTAR, TASMANIA: LNG Reliquefaction Unit

GAZ DE FRANCE, FRANCE: LNG Product Transfer