



Chilled Water

Product performance for insulation of chilled water piping





ABOUT K-FLEX USA



Youngsville, NC Headquarters



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

Designed for ease of installation and reliable performance, K-FLEX products provide excellent thermal and acoustical performance, including inherent resistance to moisture intrusion.

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 tested and certified.

In April 2012, K-FLEX USA was awarded with ISO 9001:2008 certification by FM Approvals. The independent certification demonstrates the company's commitment to quality.

K-FLEX products have proven performance in the Plumbing, HVAC/R, Commercial/Industrial, Marine, Oil & Gas, Acoustic and OEM Markets.

As a member of the IK Insulation Group, K-Flex USA delivers state-of-the-art levels of technical knowledge and customer support to the global mechanical insulation market.



COMPANY HISTORY

1965
Rubatex was formed.

1975
Halstead was formed and INSUL-TUBE® became a well-known product brand.

1989
L'Isolante K-FLEX was formed.

1999
Rubatex acquires Halstead to form RBX Industries.

2001
Nomaco Insulation and L'Isolante K-FLEX join to form Nomaco K-FLEX (NKF).



2004
NKF acquires RBX's mechanical insulation business.



2002
NKF enters into a Sales and Marketing Agreement with RBX Industries.



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 @ 75°F & Permeability: 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

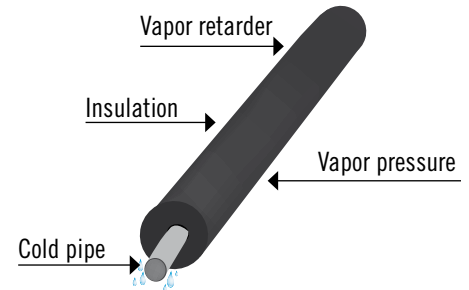
L'ISOLANTE K-FLEX:

- 11 production facilities worldwide
- Commercial distribution in 43 countries
- Headquartered in Italy

CHILLED WATER APPLICATION CONSIDERATIONS

Conditions

Below-ambient piping in a chilled water system is a very demanding insulation application as a result of the strong vapor drive towards the cold pipe, particularly in high humidity conditions. Specifically, this means the higher vapor pressure in the ambient air is trying to push the moisture-laden air towards the insulated pipe surface where the moisture vapor pressure is much lower. This unidirectional vapor pressure steadily drives against the insulation and is magnified in unconditioned spaces or under situations that the system was not designed to handle, i.e. when the chilled water system is turned on before the building is fully enclosed.



Critical Factors to Consider

Using the proper insulation material, thickness, installation procedure and maintenance has many benefits, including:

- Energy Savings
- Condensation Control
- Moisture Intrusion Prevention
- Improved Equipment Performance
- Mold / Mildew Resistance
- Improved Process Control
- Complying with Fire Safety Codes

Given the conditions of a chilled water application, using a low-perm insulation is essential for adequate system performance and cost efficiency, as the cost to replace a failed system is 3-5 times the initial cost of installation.



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. A 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 chilled water systems. For an understanding of the analysis carried out, we will refer both to the most commonly used materials (table 1) and to the

headings and sources of data presented in table 2.

Table 1

| | |
|----------|--|
| A | K-FLEX FLEXIBLE CLOSED CELL ELASTOMERIC FOAM |
| B | CELLULAR GLASS |
| C | FIBROUS |
| D | POLYISOCYANURATE |
| E | PHENOLIC |

Table 2

| | TOPIC | SOURCE OF DATA |
|----------|--------------|---|
| 1 | Performance | average values gathered from manufacturer and industry resources |
| 2 | Installation | manufacturer and industry recommendations regarding use and installation of product |
| 3 | Cost | industry values from RS Means mechanical cost data & 3E Plus operating costs data |

TECHNICAL PROPERTIES

| | K-FLEX Elastomeric | Cellular Glass | Fibrous | Polyiso-cyanurate | Phenolic |
|--|--------------------|------------------|----------------|-------------------|------------------|
| Thermal k (75°F mean) | 0.245 | 0.31 | 0.24 | 0.19 | 0.15 |
| Water Vapor Permeability without jacketing (perm-in) | 0.03 | 0.001 | 75.00 | 4.0 | 0.9 |
| Service Temperature (°F) | -297°F to +220°F | -450°F to +800°F | 0°F to +1000°F | -297°F to +300°F | -290°F to +250°F |
| Density (pcf) | 3 - 4 | 8.0 | 3 - 6 | 2.0 | 2.5 |
| Closed Cell Structure | Yes | Yes | No | 90% | 92% |
| Flexible | Yes | No (Fragile) | No | No | No |
| Requires Jacketing | No | Yes | Yes | Yes | Yes |
| ASTM E84 25/50 flame rating (2") | Yes | Yes | Yes | No | Yes |
| Self-seal closure option | Yes | No | Yes | No | Yes |
| Non-dusting | Yes | No | No | No | No |
| Non-abrasive | Yes | No | Yes | Yes | Yes |

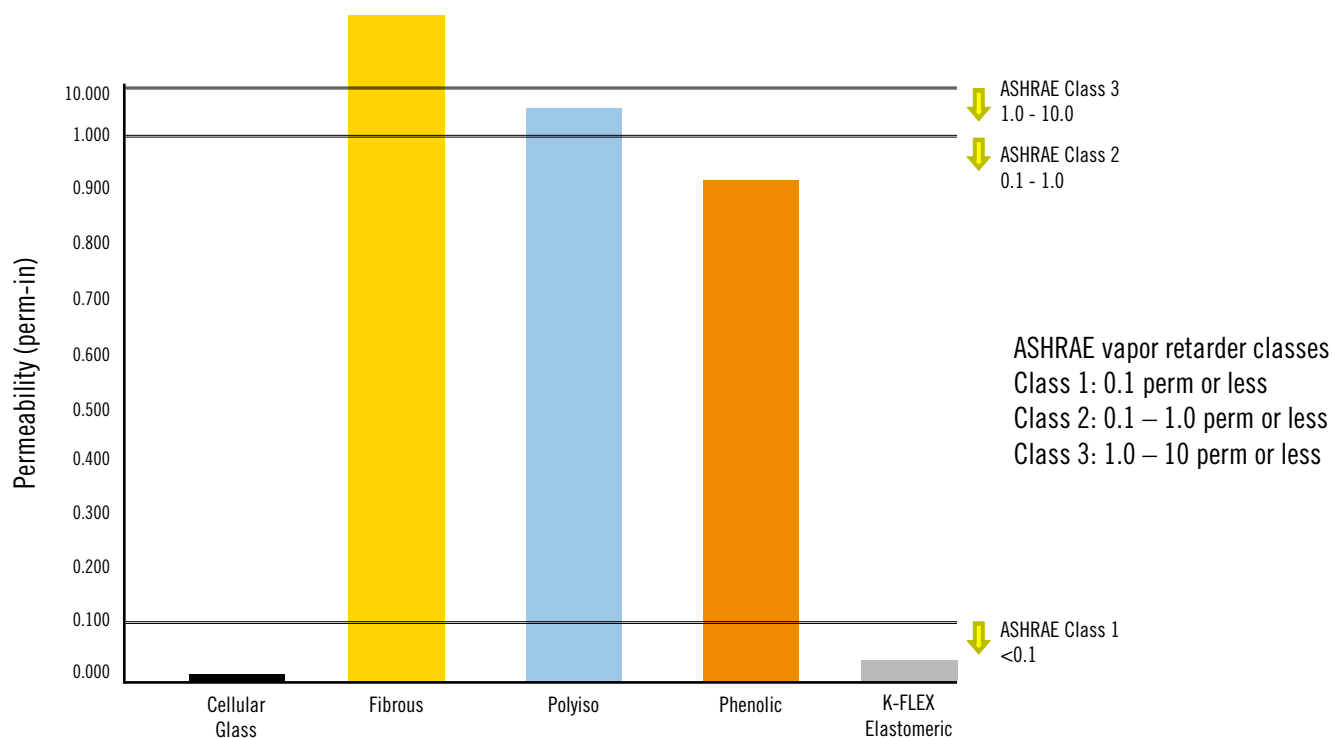
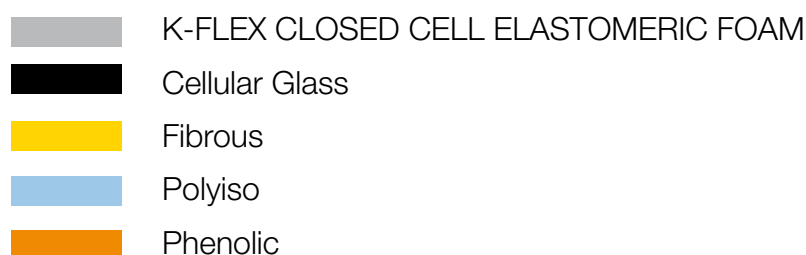
WATER VAPOR PERMEABILITY

As indicated by the detrimental effects of water vapor intrusion, the water vapor permeability of an insulation material is a critical component of its performance. If the insulation material is vapor permeable, as indicated by a high permeability (perm-in) 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 permeability would prevent

this situation from occurring. The chart below shows the permeability values for commonly used insulation materials in chilled water 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.

Permeability Comparison



| | Permeability (perm-in) |
|--------------------|------------------------|
| Cellular Glass* | 0.001 |
| Fibrous** | 75.00 |
| Polyiso* | 4.0 |
| K-FLEX Elastomeric | 0.03 |
| Phenolic* | 0.9 |

* Taken from manufacturer's published data.
** Independent industry research data.



MOISTURE GAIN & THERMAL k

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

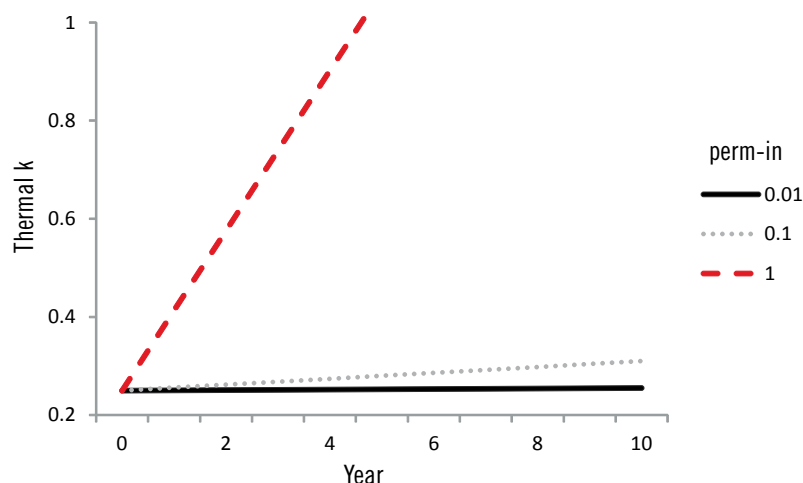
The effect of moisture gain on thermal k after 10 years is shown below. The data leads to the conclusion that *on most below-ambient systems, if the*

permeability of the insulation is less than 0.10 perm-in, there will be minimal long-term effects on the k-value.

Conditions: Ambient 90°F • Pipe 40°F • Relative Humidity 85% • Pipe Size 4" • Insulation Thickness 2" • wvt drive exists 50% of the year

| Permeability (perm-in) | .01 | .10 | 1.00 |
|------------------------|------|------|------|
| k-value (start) | .250 | .250 | .250 |
| k-value (10 years) | .255 | .310 | 1.88 |

| | k-value (75°F mean) | Permeability (perm-in) unjacketed |
|--------------------|---------------------|-----------------------------------|
| K-FLEX Elastomeric | 0.245 | 0.03 |
| Cellular Glass | 0.31 | 0.001 |
| Fibrous | 0.23 | 75.00 |
| Polyiso | 0.19 | 4.0 |
| Phenolic | 0.15 | 0.9 |

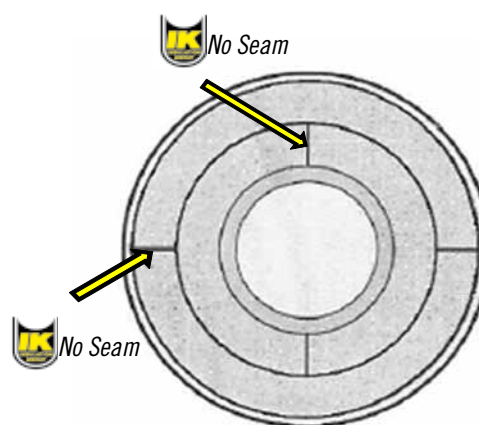


Effect of seams on risk of moisture intrusion

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 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.



| Material Type | Seams |
|---------------|-------|
| Competitive | 4 |
| K-FLEX | 2 |

CELL STRUCTURE

Another critical factor in an insulation material's ability to properly resist moisture vapor intrusion is its cell structure. In simple terms, the two types of cell structure are open and closed.

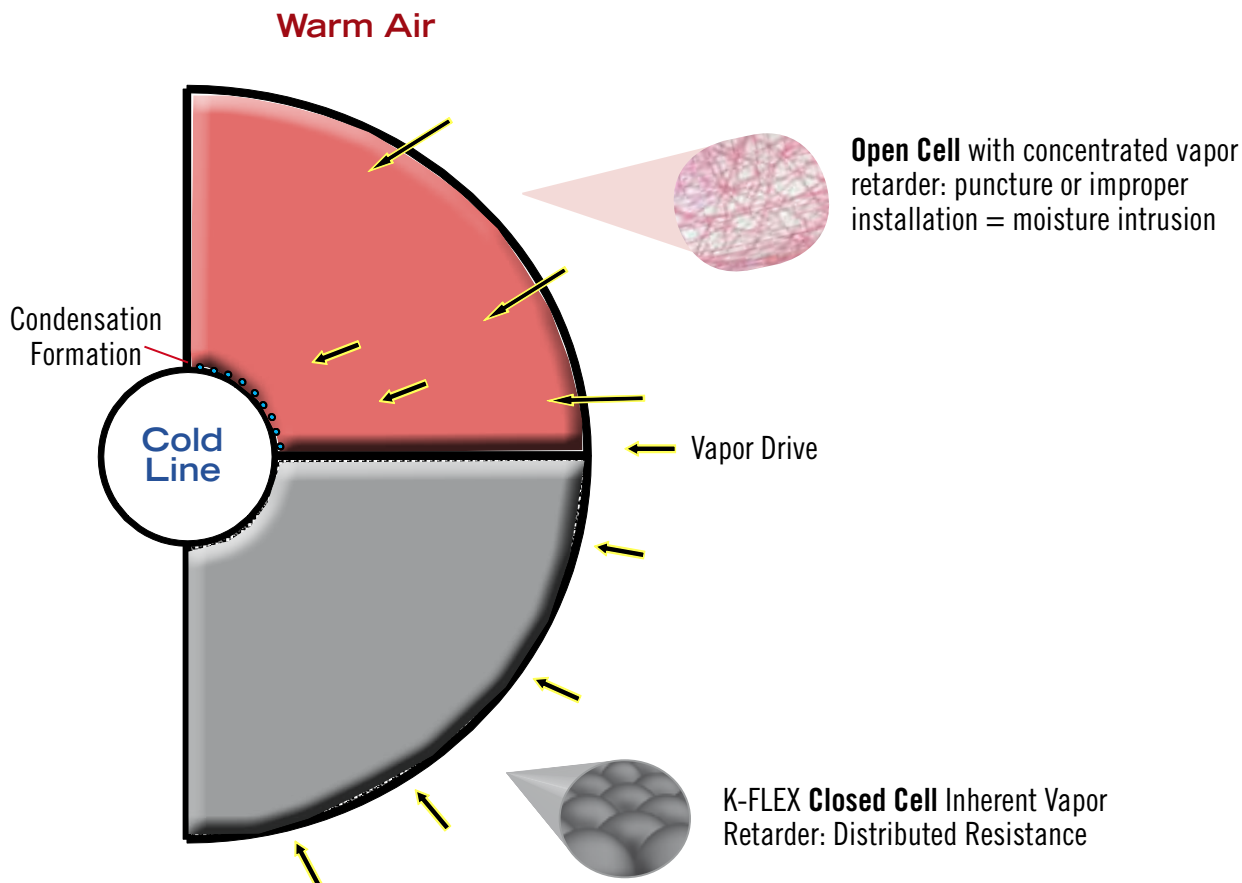
K-FLEX insulation's closed cell structure inherently resists moisture and wicking, providing distributed resistance against

moisture vapor intrusion. Additionally, elastomeric closed cell insulation materials have an established history of successful use as an insulation material for chilled water applications.

In contrast, fibrous or open cell materials are not inherently resistant to moisture and rely on a concentrated moisture vapor

barrier (jacket or surface-applied coating) 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 process.

Cell Structure Comparison





PERFORMANCE

Analysis of main features

- Low permeability without jacketing (0.03 perm-in, Class 1 vapor retarder) for lasting performance
- CUI resistance: moisture migration prevention
- Low maintenance & easy to clean
- Does not fracture from pipe vibration or expansion/contraction cycles
- Does not release fibers or particles
- Low VOC emission (GREENGUARD), CFC- and HCFC-free
- High mold & mildew resistance: Indoor Air Quality
- No fragile ASJ jacketing needed (Paper on outer surface absorbs water & supports mold growth)
- Meets Fire Codes (25/50-rated up to 2" wall)
- UV- and damage-resistant Clad[®] AL and WT available for outdoor applications

| <i>K-FLEX[®] Elastomeric Insulation</i> | | |
|--|--------------------------------------|-------------------------------|
| PROPERTY | RATING | CRITERIA |
| Operating Temperature Range (°F) | -297°F to +220°F | |
| Permeability | 0.03 perm-in | ASTM E 96 |
| Water Absorption % (volume change) | 0 | ASTM C 209 |
| Thermal k (75 °F mean) | 0.245 (Btu-in/h-ft ² -°F) | ASTM C 177 & C 518 |
| Fire Rating | 25/50 up to 2" thick Pass | ASTM E 84 NFPA 90 A / 90 B |
| Density | 3 - 4 pcf | ASTM D 1622 |
| Mold Resistance | Pass | UL 181 |
| Energy Rating | Complies | ASHRAE 90.1 & 189.1 |
| UV Weather Resistance | Pass | QUV Chamber Test |



K-FLEX[®] Elastomeric Sheet



K-FLEX[®] Elastomeric Tube


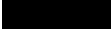



INSTALLATION & MAINTENANCE

Analysis of main features

- Flexible: non-breakable, easily conforms to uneven surfaces
- Lightweight: easy handling
- Less prone to damage from installation errors & job site abuse
- Safe to handle: No protective clothing required
- Non-abrasive, fiber-free
- Faster on-site installation (6' lengths for fewer joints)
- PSA: reduced use of contact adhesives
- Pipe Hanger Supports available
- No metal bands or on-site application of complex vapor retarder jackets
- Factory-fabricated solutions & off-site fabrication opportunities
- Non-dusting = reduced time spent vacuuming & screening work areas



Thickness to Prevent Condensation

-  K-FLEX CLOSED CELL ELASTOMERIC FOAM
-  Cellular Glass
-  Fibrous
-  Polyiso
-  Phenolic

Conditions:

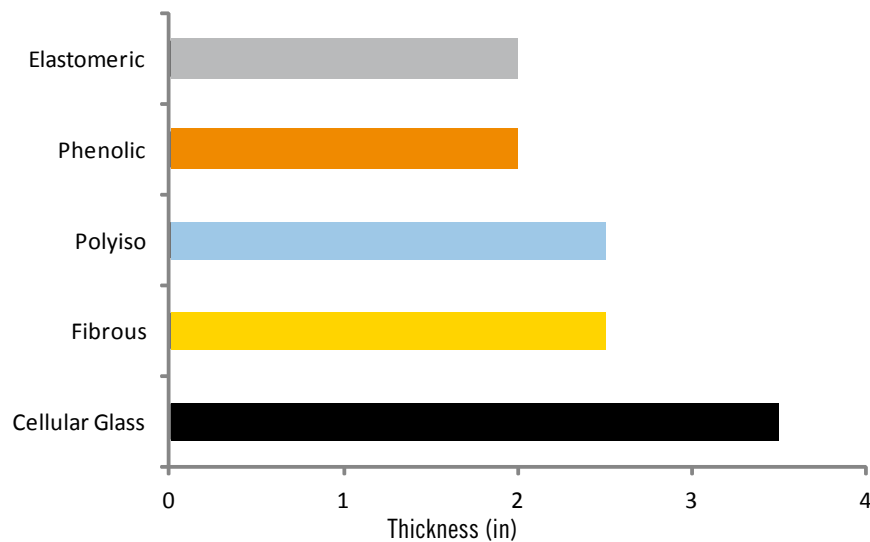
Ambient: 90°F

Pipe: 40°F

Relative Humidity: 90%

Pipe Size: 6"

| | Thickness (in.) |
|-----------------|-----------------|
| K-FLEX | 2.0 |
| Cellular Glass* | 3.5 |
| Fibrous* | 2.5 |
| Polyiso* | 2.5 |
| Phenolic* | 2.0 |



* Insulation thickness calculation based on sizes offered, thermal k, and friability of the insulation material and generated in the 3E Plus Insulation Thickness Computer Program. K-FLEX insulation thickness calculated by K-FLEX ISOCALC program, which contains current thermal k and permeability values for K-FLEX elastomeric insulation.



COSTS

Material & Labor Costs*

| | Material Cost (\$) | Labor Cost (\$) | Total Installed Cost (\$) |
|----------------------------|--------------------|-----------------|---------------------------|
| 1.5" Elastomeric | Baseline | Baseline | Baseline |
| 1.5" Cellular Glass w/ ASJ | 5% more | 30% more | 20% more |
| 1.5" Fibrous w/ ASJ | 50% less | 30% less | 40% less |

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

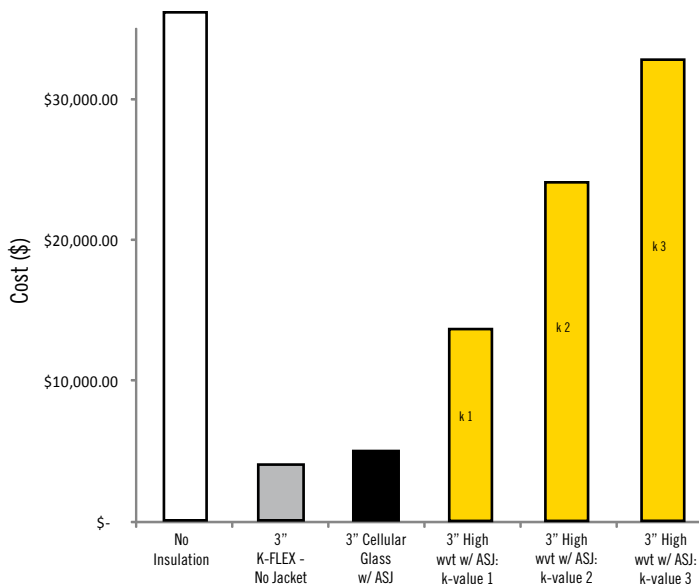
Operating Costs (Energy)

100 linear feet • Ambient Temp. 100°F • Process Temp. 42°F • Relative Humidity 90% • Pipe Size 10"

| | 10 yr. Cost (\$) |
|---------------------------------|------------------|
| No Insulation | 65,750 |
| 3" K-FLEX - no jacket | 3,880 |
| 3" Cellular Glass w/ ASJ | 4,790 |
| 3" Open Cell w/ ASJ: k-value 1* | 13,400 |
| 3" Open Cell w/ ASJ: k-value 2* | 23,420 |
| 3" Open Cell w/ ASJ: k-value 3* | 31,850 |

Energy Cost (\$) values based on cost of electricity, specifically: 3,415 Btu/kwh, \$0.10/kwh, 100% efficiency, 8320 hrs/yr.

*Based on potential k-value degradation due to moisture intrusion in materials dependent on jacketing for vapor barrier, i.e. at k-value 1, the material's k-value has risen to 1 and is a result of the relationship between moisture gain and k-value rise.



Replacement Costs

1" Phenolic foam with ASJ was specified for chilled water piping (up to 16", 45°F) in a South Florida high-rise building. With the mechanical room subject to the humid ambient South Florida air, within 2 months of installation, the ASJ failed and the phenolic foam filled with moisture. The cost to replace the problem was more than \$20 million.

Source: HPAC Engineering, March 2011

Conclusion

When comparing product types on cost, it is necessary to consider total installed cost as well as operating cost as it relates to insulation, e.g. energy loss. Beginning with total installed cost, elastomeric-based insulation is more expensive than fiberglass and less expensive than cellular glass.

Factoring in performance and its associated operating costs shows that elastomeric is comparable to cellular glass, giving the overall advantage to elastomeric. Elastomeric is more expensive to install than fibrous material, but the fibrous material's porous structure and subsequent moisture

intrusion if the vapor retarder jacket is punctured brings a high level of risk for substantially higher operating costs (high energy use and system replacement) that cannot be overcome by installed cost savings.

PROJECT: CALIFORNIA STREET THERMAL PLANT

Location: Omaha, NE (average 87°F and 85% RH in summer conditions)

Application: Chilled (38°F), Condenser & Domestic Water; Range of 6" to 42" piping

Owner: Omaha Energy Systems Company

Mechanical Engineer: Farris Engineering

Insulation Subcontractor: Mid-Plains Insulation

2003: K-FLEX® Elastomeric Tube and Sheet installed on time and within budget

- Elastomeric was specified for its reliability against condensation and secure fit at seams
- K-FLEX® Elastomeric Insulation's flexibility allowed it to conform to irregular surfaces

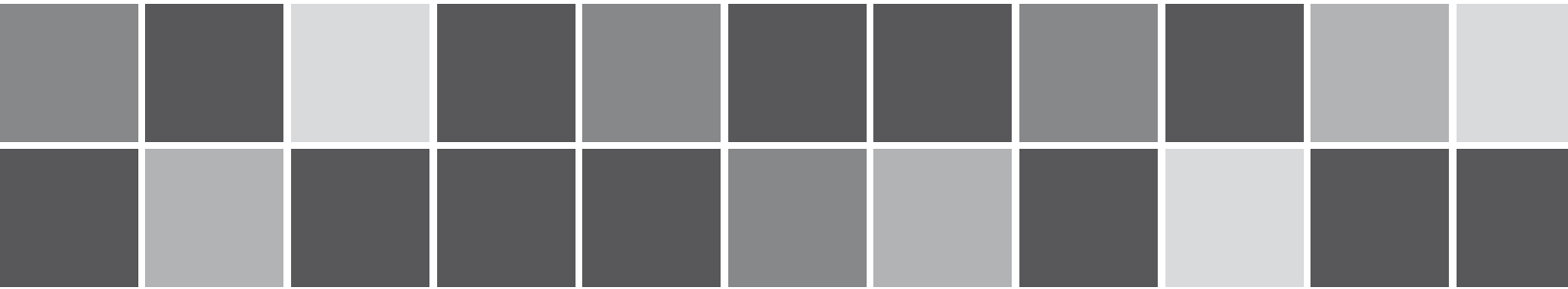
2012: K-FLEX still performing well

- No condensation or insulation failure





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