INSULATING OUTDOOR LARGE DIAMETER PIPE AND ROUND DUCT WITH K-FLEX SHEET INSULATION

Large diameter, outdoor round ducts create special issues when they are insulated with a closed-cell insulation product vs. an open-cell / fibrous product. The issues are created by the inherent expansion and contraction that a closed-cell product will exhibit as a result of temperature change caused by either variations of the process temperature in the duct/pipe or, more importantly, fluctuations in the ambient air temperature and the interaction with the jacketing that is applied. Flat surfaces do not have this issue, as typically the expansive forces are more evenly distributed over shorter sections.

Factors to consider are:

1. All outside applications require a protective cover / jacket of some kind. This jacket may not have the same expansion/contraction coefficient as the insulation.
2. Size of duct or pipe
3. Thickness and number of layers of insulation
4. Type of jacketing used
5. Temperature change from installation to operation and temperature fluctuation (both internal and external)

The goal is to ensure the seams of the insulation can withstand the expansive forces of the duct/pipe and, of key importance, that the jacket seams can withstand the expansive forces of the insulation. If the force encountered due to the expansion/contraction caused by the temperature fluctuations are not accounted for, the seams of the insulation/jacket may separate and/or wrinkles may occur at the jacket seam on fully adhered jacketing systems. The larger the duct/pipe (with thicker insulation and greater temperature variations), the greater the effect they will have.

Recommendations:

1. Use “best practice” installation recommendations (i.e. ASTM C1710 “Standard Guide for Installation of Flexible Closed Cell Preformed Insulation in Tube and Sheet Form”), such as adhering all seams securely using proper adhesive application. When multiple layers of insulation are used to achieve the thickness required, stagger the seams and do not adhere the layers to each other or to the duct/pipe. This will allow greater slippage between layers. The insulation layers or jacket should not be stretched or installed under tension.

2. When possible, minimize the temperature differential (Δ T) by installing the insulation at an ambient temperature midway between normal environmental conditions (i.e. 40°F to 100°F, preferably around 75°F). Also, install the insulation when the system is turned off. This will reduce the temperature differential during operation, thus minimizing the effects of expansion / contraction.

3. When selecting the type of jacket used and the method of securing the jacket seams, consider the forces the system may encounter due to the expansion and contraction of the system during normal

operating conditions. The jacket must allow for this expansion or be strong enough to withstand these forces. When considering the jacket seam, one has to consider the secondary heat from the environment created by the sun and its effect on the adhesive coating used on the seam or overlap. Many PSAs weaken when exposed to heat. The amount of overlap and the use of rivets will affect the strength of the seam. A “typical” PSA seam tape is not sufficient to hold the jacket seam shut as the PSA will soften and may slip due to heat and expansive forces. All seams should be made with solvent-based contact adhesives, which are less susceptible to the effects of heat. For this reason, K-FLEX recommends only field-applying jacketing (not factory-applied K-FLEX Clad® sheet) and following the installation process outlined in the K-FLEX Installation Manual.

Typical jacketing materials would include PVC, metal or an elastomeric membrane. Protective flexible coatings can also be used, as long as the elasticity of the coating is greater than the expansion of the insulation. If it is not, the coating may crack or egg shell. Each has its benefits and drawbacks, as well as cost and appearance considerations. PVC is the lowest cost but not typically recommended for outdoor applications, metal would provide the greatest strength and can be oversized to accommodate some expansion but bands may loosen in cold temperatures due to insulation shrinkage, while the elastomeric membrane would expand and contract with the insulation.

Using a combination of materials may be the best way to overcome the expansion of forces on the jacket created by the closed cell foam insulation. A thin layer (1/4” – 1”) of a semi-open cell (crushed foam) product or fibrous material coupled with 1” – 3” of a closed cell foam insulation will compensate for the forces exerted on the jacket, eliminating wrinkling or seam separation. Contact K-Flex Technical for information on specific recommendations.

Round ducts or pipes can be insulated successfully with elastomeric closed-cell insulation, however care must be taken to consider all the factors in play during the installation and operation of the system. Because of the number of variables, only general recommendations can be given in a technical bulletin of this type. Consult K-FLEX USA with specific details for more detailed recommendations.

Addendum to Insulating Large Diameter Pipe or Round Duct

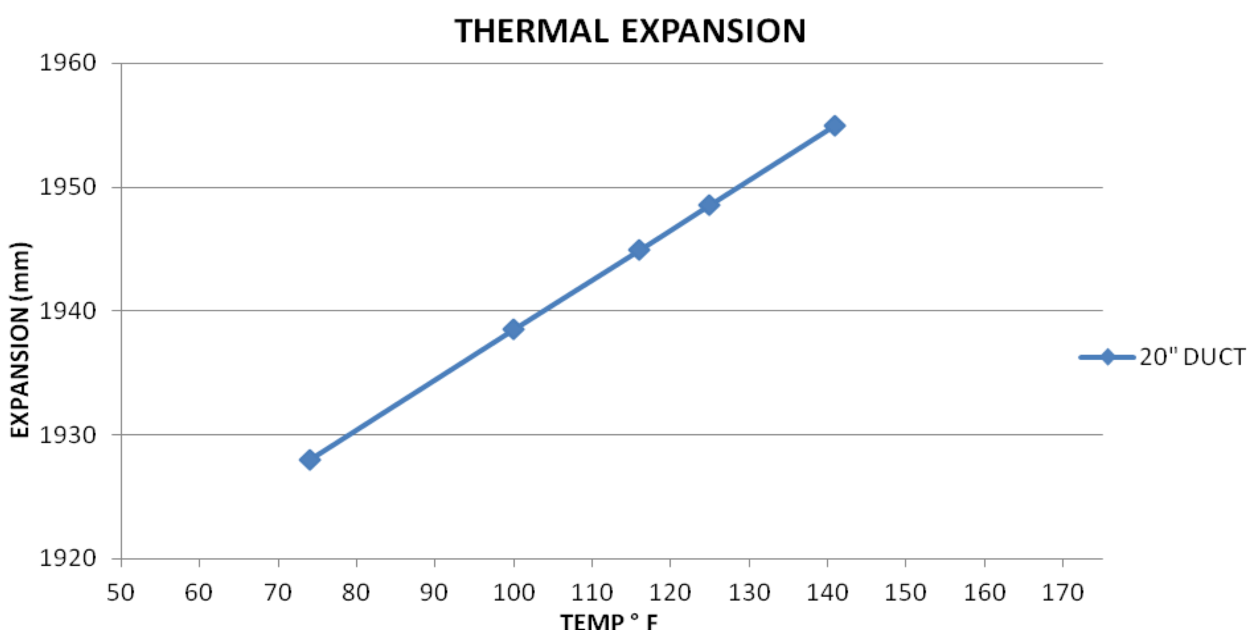
<u>Technical Background</u>

Several physical properties/factors enter into the selection and proper installation of insulation and jacketing on a large diameter pipe or duct. These would include:

- Coefficient of expansion and contraction (COLTE) of the insulation (% per degree Fahrenheit)
- Compressive/expansive forces of the insulation (psi)
- Diameter of the duct/pipe (in)
- Thickness of the jacket (in)
- Hoop stress on the jacket (psi)
- Strength of the jacket seam (psi)

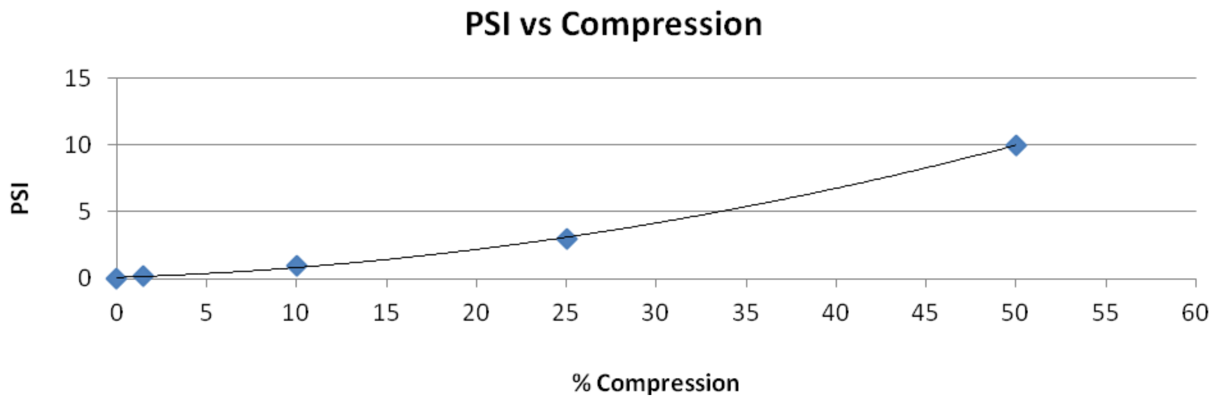
The objective is to have the jacket seam strength greater than the hoop stress. The graphs and formulas define how to determine if the jacket will withstand the expansion forces of the insulation due to temperature increase. The graphs are used to determine the expansive forces on a 40" diameter duct with a 40°F temperature gradient insulated with 2" of elastomeric insulation and jacketed with a .015" PVC sheet.

1. Coefficient of Linear Expansion



Coefficient of linear expansion = .00021%/°F
(circumference of large ID (20") elastomeric duct)
% expansion with a 40°F temperature change = 0.85%

2. Compressive Forces of Elastomeric Insulation



Psi at 1.5% expansion = .2 psi
The 1.5% expansion allows for a safety factor over what is expected for a 40°F gradient.

3. Determination of hoop stress on jacket

Determining the hoop stress on a jacketed insulated duct is similar to determining the hoop stress produced as a result of forces (pressure) applied from inside a cylindrical pipe pushing against the pipe. Using Newton's first law of physics, the following formula can be used to derive the hoop stress pressures.

$\sigma = PR/T$

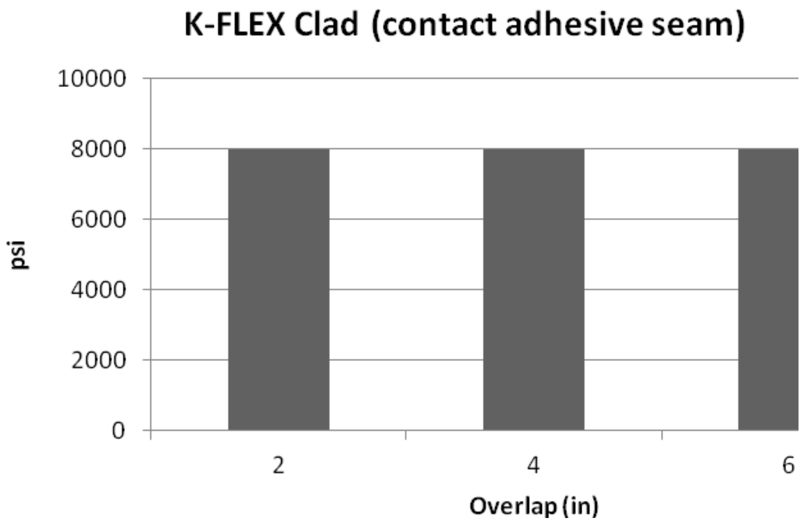
σ = hoop stress
P = internal pressure
R = radius
T = thickness of jacket

Given:
The duct is 40" with 2" of insulation.
The internal pressure is 0.2 psi (see graph #2).
The jacket thickness is .015" thick.

$\sigma = PR/T = (.2\text{psi} * 21\text{in}) / .015\text{in} = 280$ psi hoop stress

4. Seam Strength

Various seam configurations were evaluated for sheer strength.



Using a contact adhesive to adhere the seam, the K-FLEX Clad® failed before the seam did. All configurations tested the same.

5. Effect of Duct on Hoop Stress

Constant: 40°F gradient = .2 psi pressure

Jacket thickness = .015”

σ = PR/T

Duct Diameter	40”	20”	10”	5”
	.2 (20)	.2 (10)	.2 (5)	.2 (2.5)
	.015	.015	.015	.015
Hoop Stress (psi)	266	133	66	33

6. Conclusion

Based on the calculation of the hoop stress exerted (266 psi) and the strength of the K-FLEX Clad® (with a contact adhesive seam) of 8,000 psi, the seams should never fail.

We were not able to test the seams in a heated state. A PSA seam would exhibit a loss of strength in this type of environment.

Recommendation:

Using a 2” overlap with a contact adhesive seam should provide an acceptable installation recommendation for K-FLEX Clad® used on large diameter outdoor duct or pipe.