Preventing Kinking in Tubing:

Strategies for Reliable Fluid Transfer

Kinking of tubing is a pervasive issue that transcends industries, with potentially dire consequences. When tubing kinks, it not only restricts flow and impairs product integrity but also poses safety hazards. In sectors where precision is paramount, like biopharma and food and beverage, kinking can lead to significant setbacks.

Addressing tube kinking requires a multifaceted approach that tackles factors such as material and mechanical properties, bend radius, tube diameter, wall thickness, and external forces on the tube when in use. Engineers, manufacturers, and operators must employ a variety of strategies, carefully balancing different requirements to ensure the optimal functioning of the tubing.

Material Matters:
Finding the Perfect Polymer Pairing

The process of selecting the right tubing material requires a deep understanding of the polymer's inherent properties and their alignment with application needs. For instance, polyurethane's flexibility and kink resistance make it ideal for a robotic arm manipulating delicate objects. Conversely, silicone is superior in biocompatibility and temperature resistance for medical devices like laparoscopic insufflators. Comprehending the intricate interplay between the polymeric material utilized in tubing applications and the specific application is essential to avoid missteps that could result in kinking.

Table 1 (pg. 2) details some more materials and applications and compatibility information for each.

Selecting the Right Tube

Material and Mechanical Properties

Bend Radius

Tube Diameter

Wall Thickness

External Forces

Taming Kinks:
Smart Design Strategies

Kinking in polymer tubes can also result from insufficient support to counter external pressures. These stressors include the weight of the transported fluid, the tube's own mass, changes in flow rate during operation, and sharp bends or junctions where the tube must flex.

Table 1

MATERIAL	USES	CHEMICAL COMPATIBILITY	APPLICATION
Polyvinyl Chloride (PVC)	General fluid transfer	Good with water, weak acids, alkalis	Water supply, irrigation, industrial fluids
Polyethylene (PE)	General fluid transfer	Excellent with water, many chemicals	Water, food, non-corrosive liquids
Polypropylene (PP)	General fluid transfer	Excellent with water, acids, alkalis	Water, chemicals, industrial fluids
Thermoplastic Elastomers (TPE)	Flexible and durable tubing	Good with water, mild chemicals	Medical tubing, laboratory fluid handling
Polyurethane (PU)	Flexible and kink-resistant	Good with water, oils, some solvents	Pneumatic systems, robotics, automotive
Fluoropolymers (e.g., PTFE, FEP, PFA)	Corrosive chemicals and high temperatures	Excellent with most chemicals, high temperatures	Corrosive chemical handling, biopharmaceuticals
Silicone	Biocompatible and temperature resistant	Biocompatible and temperature resistant	Biopharmaceuticals, medical applications

Bend Radii

Bend Radii is the minimum radius of curvature that a tube can bend without kinking

Bend It Like a Pro:
Bend Radii and Thickness

Plot 1 (page 3) illustrates the average bend radii, the minimum radius of curvature that a tube can bend without kinking, of platinum cured silicone tubing. The procedure, adapted from ISO 10619, involved winding the tubing around a mandrel of known diameter and gradually reducing the mandrel diameter until a kink appeared. The point of kinking was defined as when the midpoint's outer diameter of the tubing decreased by over 20% from its original size. The test samples were categorized by their inner diameters to facilitate a comparison of bend radii. At each specified diameter, the tubing could bend around smaller mandrels without kinking as the wall thickness and outer diameter increased. This observation indicates that larger silicone tubing dimensions (>0.5" ID) necessitate a substantial wall thickness to effectively resist kinking.

Bending Back:
Bend Radius, Flexibility, Structural Rigidity

The flexibility of a tube is inversely proportional to its bend radius. This means

Inner Diameter

Silicone tubes with larger IDs are more likely than those with smaller IDs to kink when bent

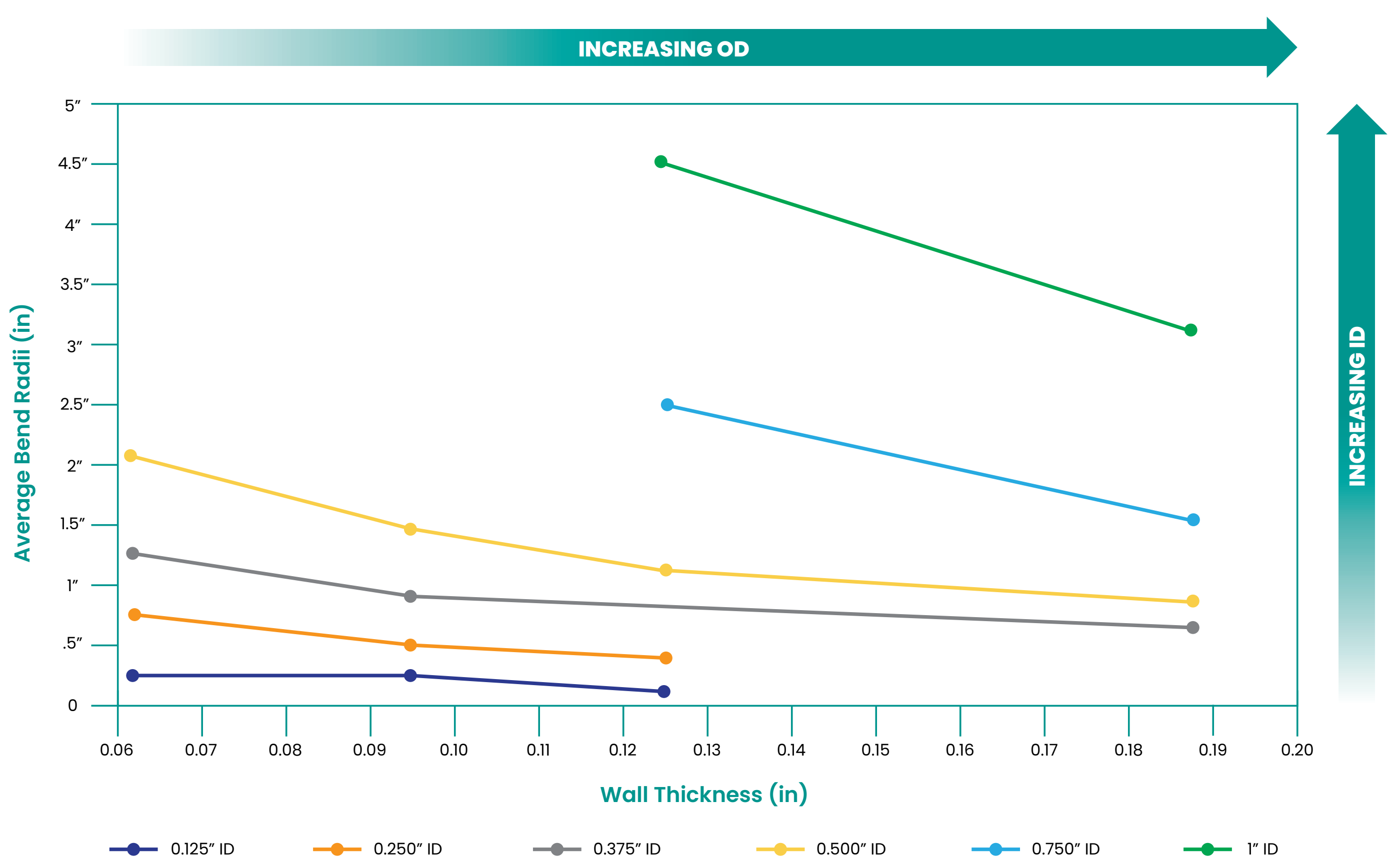
that a smaller bend radius will require a more flexible tube. The bend radii can also be reduced by using a tube of smaller diameter, so long as it is an appropriate dimension for the application.

However, increased flexibility can come at the expense of structural rigidity. A method to reduce a tube's ability to kink or collapse is to incorporate a reinforcement into the design of the tube. Reinforced tubing is a type of flexible tubing that includes additional layers or materials to enhance its structural integrity, strength, and resistance to certain forces like pressure, kinking, and collapse.

The reinforcement is added to the tubing during the manufacturing process, and can be made from various materials, such as braided fibers, spiral wire, or textile materials. Typically, the reinforced tube is comprised of three layers: a core, the braid, and then the jacket; where the core and the jacket can be the same or different materials, depending on the end use.

In braided reinforcement constructions, braided fibers, commonly made of materials like nylon, polyester, or aramid, are embedded within the tubing wall. In spiral reinforcement, a wire helix is embedded within the tubing's structure, offering enhanced flexibility, collapse resistance, and protection against crushing.

Plot 1



The benefits of reinforced tubing, such as improved pressure and kink resistance, often outweigh the drawbacks, particularly in demanding fluid transfer.

Striking the balance between the stressors placed in the tube by the material flowing in it, the velocity, etc., and the bends needed in the system is important. If the tubing is too flexible, it may not be able to withstand the forces imposed on it. If the tubing is too rigid, it may not be able to bend enough to make the necessary turns.

Tube Thickness

Tubes with more thickness were better able to resist kinking when bent than their thinner counterparts.

The Vital Art of Tubing: Installation and Management

Proper installation of tubing is necessary to prevent kinking, which can disrupt fluid flow and compromise the tubing's integrity.

Below are a few bending techniques that can help increase the life and performance of the tube when in use:

Use smooth, gradual bends that meet tubing recommendations; consider tube benders for proper bend radii.
Opt for elbow fittings to change tubing direction, preventing sharp bends and preserving tubing integrity.
Avoid excessive stretching or twisting to prevent stress points and potential kinks.
Allow adequate slack without sagging, securing with clamps or brackets as needed.
Ensure careful routing and secure fastening to prevent compression or damage.
Regularly inspect tubing for wear, kinks, or damage; promptly replace compromised tubing.

Conclusion: No Kinks, All success

Kinking within tubing has implications across diverse applications, spanning medical, industrial, aerospace, and food and beverage sectors. Excessive bending or folding of tubing can trigger partial or complete blockages, impeding fluid flow and disrupting critical processes.

In industrial settings, kinks within fluid transfer lines can trigger equipment malfunctions, hazardous spills, or production interruptions. Aerospace and aviation sectors face the risk of compromised flight safety and control due to kinks in hydraulic or fuel lines. Additionally, kinking can result in diminished flow rates, pressure drops, and increased stress on tubing materials, potentially causing premature wear, leaks, and compromised product quality.

Therefore, prioritizing kink prevention is pivotal to ensure the dependability, efficiency, and safety of various applications. Kinking traits vary across materials and constructions, underscoring the importance of testing the chosen material for the specific application before implementation.

While tips and techniques provide valuable insights, establishing a partnership with a reputable vendor can prove even more beneficial. NewAge Industries has over 20 years of experience in the tubing industry and is ISO 9001 certified. We have a skilled team of engineers and technicians who can help you select the right tubing for your application and ensure that it is installed properly. We also offer a wide range of tubing products and services, including custom tubing solutions.

About NewAge Industries:

In business since 1954, NewAge Industries manufactures plastic and rubber tubing in reinforced and unreinforced styles. The company maintains a large inventory of tubing and fittings for its core product lines, provides custom extrusion and fabrication capabilities, and services customers worldwide. The AdvantaPure ® division of NewAge Industries specializes in high purity tubing, hose, single-use process tubing manifolds, AdvantaFlex® TPE tubing, AdvantaSil® silicone tubing and hose, BioClosure® container closure systems, and other molded components for the pharmaceutical and biopharma industries. Products are manufactured, stored, and shipped using methods that ensure product purity. Automated product identification systems, including gamma stable RFID tags and labels, are offered by NewAge's Verigenics® division. Additionally, NewAge Industries is proud to be ISO 9001 certified, demonstrating our commitment to quality and continuous improvement.