Selecting Elbows for Pneumatic Conveying Systems

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The right elbow can keep your system operating at peak performance, reduce maintenance costs, and minimize material attrition and elbow wear. This article describes common elbows and outlines factors to consider when selecting one.

Several types of elbows (also called bends or sweeps) are available for pneumatic conveying lines. Each design is suited to certain applications and has its own set of advantages and disadvantages. The elbow you choose influences the pneumatic conveying system's performance, whether the system operates in dense or dilute phase and whether under pressure or vacuum.

An elbow provides a change in material-flow direction. This adds pressure losses to the system due to impact, friction and re-acceleration.

As product enters the inlet of the elbow, it typically continues moving straight ahead to the first (or primary) impact zone. The product is then deflected at an angle toward the outlet of the elbow. The deflection angle is determined by the elbow design, the product's characteristics, the conveying velocity, and the specific load (also called the product-to-gas ratio). In many designs, the product will hit one or more secondary impact zones before exiting the elbow.

Impact forces can cause severe degradation of fragile or breakage-sensitive products, generating a large amount of fines or dust and creating quality issues. Heat-sensitive products, such as plastic pellets, can overheat on the contact surface); this can result in unwanted tails or streamers on the pellet or film build-up on the surface of the elbow, which can eventually lead to product contamination. Abrasive products can cause wear, leading to worn-out elbows and system leaks and causing maintenance and safety issues.

Basic designs

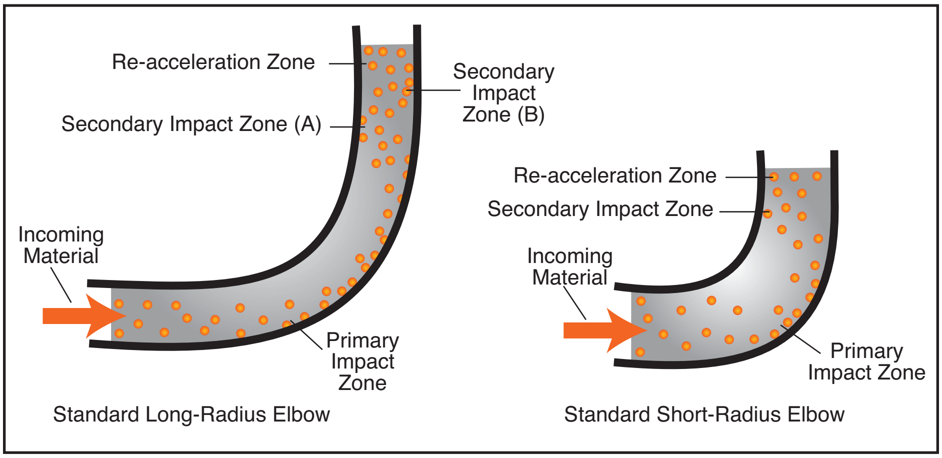
Elbows fall into two main categories:

- standard elbows
- specialty elbows.

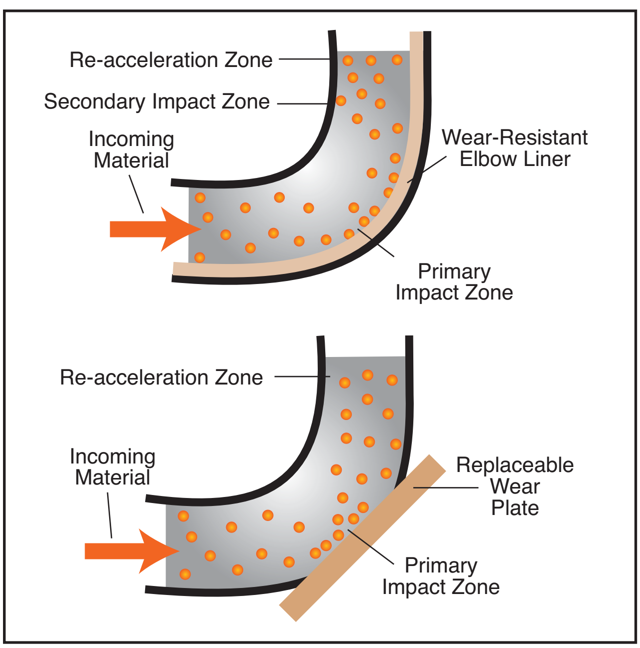
A standard elbow is simply a straight pipe section that has been bent. The angle and centerline radius of the elbow can (at a given velocity) influence pressure loss across the elbow. Additional pressure losses are caused primarily by friction (as the product concentrates and presses against the outside wall of the elbow) and/or impact losses (as elastic products bounce from one impact zone to another). Traditional standard elbows are typically used for bulk materials with no physical or thermal degradation issues.

Specialty elbow designs provide a controlled flow pattern to create, ideally, one impact zone where product hits other product instead of sliding along the elbow wall. They are typically used when conveying fragile or temperature-sensitive products.

The material's phase and velocity changes affect the pressure loss of specialty elbows. These devices typically have higher pressure drops than standard elbows. The differences can vary significantly, depending on the product's characteristics, system operating conditions (such as conveying velocities and product-to-gas ratios), and, of course, elbow design (the blind-tee elbow has the highest pressure loss).



■ Figure 1. Standard elbows are made by bending a straight section of pipe.



■ Figure 2. A ceramic liner (top) or an impact plate (bottom) can be added to increase the useful life of a short-radius elbow.

Standard elbows

Made by bending a straight pipe, standard elbows are available in either long-radius or short-radius designs (Figure 1). Long-radius elbows typically have a centerline radius that is eight or more times the pipe diameter, whereas short-radius elbows have a centerline radius that is three to five times the diameter. Their advantages, limitations and applications are similar.

Advantages. Standard elbows are readily available in almost all materials of construction and sizes, and with a variety of different elbow angles. They have low pressure losses, and because there is no change in diameter, there are no cross-contamination issues. They also have low costs.

Disadvantages. Standard elbows need internal surface treatment when abrasive products are to be handled. Fragile products are subject to significant degradation due to the existence of multiple impact zones. Pellets or granular products generate high noise levels in standard elbows. And heat-sensitive products can smear and build up on the inside of the elbow. Standard elbows have low pressure losses; depending on the conveying velocity, the pressure loss across a short-radius elbow can be lower than that of a comparable long-radius elbow. The long-radius elbow requires a large space for installation, a short-radius elbow less space.

Recommended applications include the handling of powders or pellets that are non-abrasive, are not fragile, and have high melting points, in either dilute-phase or dense-phase systems. Short-radius elbows are nearly always preferred over long-radius ones, unless the latter would be easier to install.

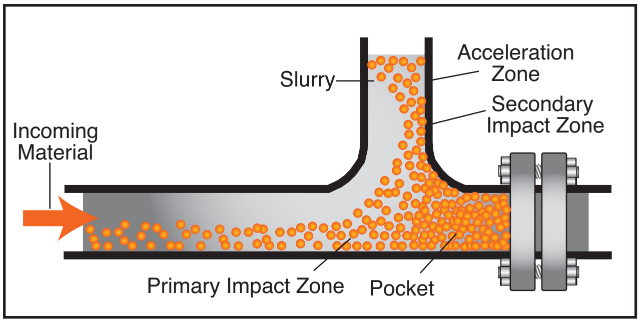
Special short-radius elbow designs

Several specialty short-radius elbows are available, primarily for abrasive products. They typically have a liner or a wear-plate insert in the primary impact area (Figure 2). If that wears through, only the liner or wear plate needs to be replaced, not the entire elbow. Variations with different angles are available.

Advantages. Like the standard elbows, these styles are available in almost all materials and sizes and with different angles. They require less space for installation than standard long-radius elbows. And, because only the wear plate or liner needs to be replaced in case of wear-through, replacement costs are lower.

Disadvantages. Like standard elbows, these require internal surface treatment for handling abrasive products, their multiple impact zones can cause fragile products to degrade, pellets or granular products generate high noise levels, and intense exposure of heat-sensitive product to the elbow walls can cause the product to smear and build up inside the elbow. Changes in the elbow's cross-sectional area cause higher pressure losses, and dead corners raise product contamination issues.

Recommended applications include the handling of powders or pellets that are moderately abrasive, have high melting points, and are not fragile. They are suitable for dilute-phase pellet and powder systems, but only for powders in dense-phase systems.



■ Figure 3. In a blind-tee elbow, product-to-product impact reduces the contact of particles against the elbow wall.

Blind-tee elbow

The blind-tee elbow (Figure 3) creates a product-to-product primary impact zone and eliminates the high-impact contact of incoming particles against the elbow wall. This reduces wear as well as degradation of fragile and heat-sensitive products.

Advantages. The blind-tee elbow can be made of different materials and with different angles. Its compact design requires less space than standard elbows, making it easy to retrofit. Wear and product degradation are low due to its product-to-product primary impact zone. It is the lowest-cost specialty elbow.

Disadvantages. The blind-tee has extremely high pressure losses. Dead zones and product pockets may lead to product cross-contamination. The secondary impact zone can raise wear and degradation issues.

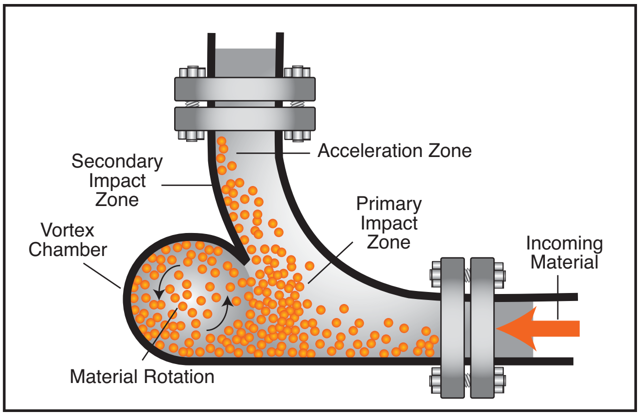
Recommended applications are short, dilute- or dense-phase systems with dedicated product lines where product pockets are not critical. It can handle pellets or fluidizable powders that are abrasive, heat-sensitive or fragile.

Spherical-chamber elbow

This elbow, trade-named the Smart Elbow (from HammerTek Corp., Landisville, PA, www.hammertek.com) has a spherical vortex chamber opposite its inlet (Figure 4). The chamber's shape and location force the material into a rotating motion, producing a product-to-product primary impact zone at the entrance area of the chamber. The impact zone deflects the incoming particles upward at an angle toward the secondary impact zone, the re-acceleration zone, and eventually the elbow exit. It is available in 45-deg and 90-deg versions.

Advantages. This elbow is available in aluminum, stainless steel, carbon steel and special alloys. It has a defined primary product-to-product impact zone, a compact design with low space requirements, and low noise levels. It is suitable for both powder and pellet transfer.

Disadvantages. Depending on the velocity conditions, there is a high risk for product cross-contamination (although



■ Figure 4. In the spherical-chamber elbow, the rotating motion of the particles creates a product-to-product primary impact zone.

this is not an issue if the conveying line is dedicated to a single product). The product rotation in the chamber causes fragile products to degrade. Due to the deflection angle, a secondary impact zone may form, where wear and degradation can occur. Pressure loss is higher than that of standard long- and short-radius elbows; actual pressure loss depends on the product, with powders having lower pressure drops than pellets.

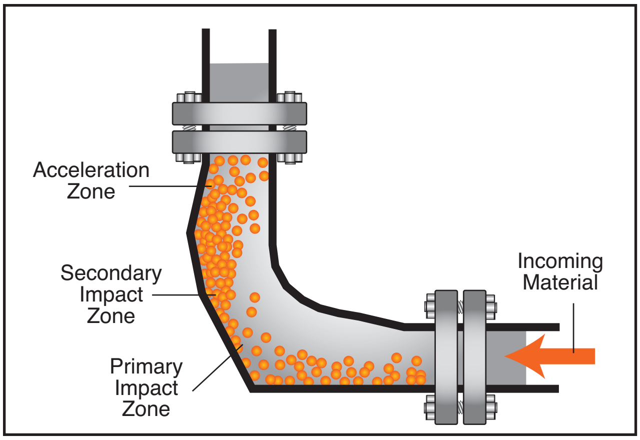
Recommended applications involve the handling of fluidizable powder products and pellets that are abrasive, heat-sensitive and/or fragile. It can handle dilute- or dense-phase powders, and dilute-phase pellets.

Gamma Bend

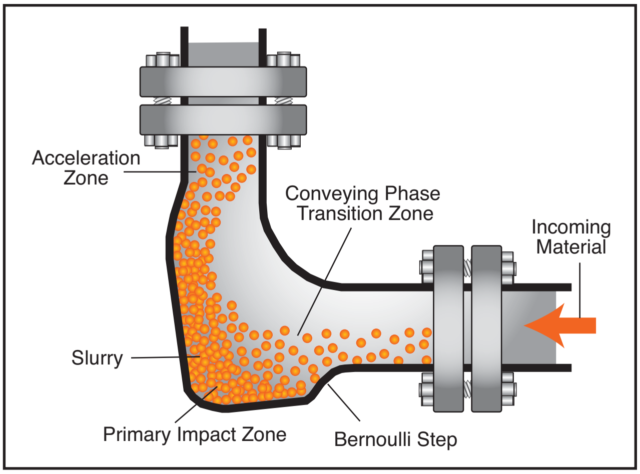
Developed to eliminate the formation of streamers during the dilute-phase conveying of plastic pellets, the proprietary Gamma Bend elbow (from Coperion Waeschle, Weingarten, Germany, www.coperion.com) features a cross-sectional area change beyond the inlet, which slows down the incoming particles (Figure 5). The specific angle of the back side of the elbow determines the deflection pattern and defines the product-to-product impact zone. The thickness of the product layer in the impact zone is determined by the product-to-gas ratio, and is optimized for typical dilute-phase design parameters. In front of the elbow exit, the widened area transitions back to the diameter of the pipe, re-accelerating the moving particles and creating the protective product layer. Due to the angle and area ratios, the protective product layer covers the entire back side of the elbow, providing a large impact and wear-protection zone. This elbow is available only with a 90-deg. angle.

Advantages. The Gamma Bend has a defined primary product-to-product impact zone, and a compact design with low space requirements. It has only a slightly higher pressure loss than standard long- and short-radius elbows, and it has low noise levels.

Disadvantages. Depending on the velocity conditions,



■ Figure 5. A cross-sectional area change beyond the inlet of the Gamma Bend elbow slows down the incoming particles and allows a protective layer of product to form on the back side of the elbow.



■ Figure 6. A step near the Pellbow's inlet prevents particle accumulation by creating a low-pressure zone that draws product across the elbow's bottom.

there is some risk for cross-contamination of product. The creation of the product-to-product impact zone requires the maintenance of minimum product-to-gas ratios (approximately 5:1). This elbow is available only in stainless steel, and is suitable for pellets or granular products only.

Recommended applications are the dilute-phase handling of heat-sensitive or abrasive plastic pellets and granules.

Pellbow

This patented elbow design (from Pelletron Corp., Lancaster, PA, www.pelletroncorp.com) resembles a standard short-radius elbow with a large expanded chamber between the inlet and discharge of the elbow (Figure 6). After the inlet, a sharp step creates an area expansion within the elbow and a deceleration zone for the incoming particles. This slowdown leads to the formation of a fluidized slurry in the product-to-product primary impact zone (as in the Gamma Bend elbow). The slurry constantly moves upward toward the discharge and re-acceleration zone at the elbow exit.

The step just inside the elbow inlet creates a low-pressure zone that draws the product from the primary impact zone back across the elbow's bottom toward the inlet and into the main product stream. This allows a complete clean-out that is less sensitive to the actual conveying velocities than other elbows. It is available with a 90-deg. angle.

Advantages. This elbow's benefits include a defined primary product-to-product impact zone, a compact design with low space requirements, and low noise levels. Its pressure loss is only slightly higher than that of standard long- and short-radius elbows. It is available in aluminum, stainless steel, carbon steel and special alloys, and is suitable for pellet and powder transfer. The step eliminates the build-up of product within the elbow, allowing for a complete purge.

Disadvantages. The creation of the product-to-product

Table. When selecting an elbow, consider the product's characteristics and velocity.

LR = Standard Long-Radius Elbow; SR = Standard Short-Radius Elbow; SpcSR = Special Versions of Short-Radius Elbows; BT = Blind Tee; SE = Smart Elbow; GB = Gamma Bend; PLB = Pellbow

	Powders		Pellets	
Product Characteristic	Dense Phase, Low Velocity (< 15 m/s)	Dilute Phase, High Velocity (> 15 m/s)	Dense Phase, Low Velocity (< 15 m/s)	Dilute Phase, High Velocity (> 15 m/s)
Non-abrasive and not temperature-sensitive	LR, SR	LR, SR	LR, SR	LR, SR
Abrasive	LR, SR	SpcSR, BT, SE, PLB	LR, SR	SpcSR, BT, SE, GB, PLB
Temperature-sensitive	LR, SR	BT, SE, PLB	LR, SR	BT, SE, GB, PLB
Fragile	LR, SR	BT, SE, PLB	LR, SR	BT, SE, GB, PLB
Cohesive	LR, SR	LR, SR	LR, SR	LR, SR
Highly elastic	LR, SR	LR, SR	LR, SR	LR, SR

impact zone requires a minimum product-to-gas ratio of approximately 3:1.

Recommended applications include the handling of fluidizable powder products and pellets that are abrasive, heat-sensitive and/or fragile. It can handle the dilute- or dense-phase transfer of powders, and the dilute-phase conveying of pellets.

Choosing an elbow

Selecting an elbow requires knowledge of the product to be conveyed — whether it is abrasive, temperature-sensitive, fragile, cohesive or elastic — and of the pneumatic conveying system — primarily whether it involves dilute-phase or dense-phase flow.

In dilute-phase conveying, the air velocity is high enough to keep the material being transported airborne. The material is conveyed continuously and does not accumulate in the conveying line. The air velocity needed to suspend the particles is known as the saltation velocity.

Dense-phase conveying takes place at lower velocities. The material lays for periods of time on the bottom of a horizontal line. Fluidizable products generally flow through the conveying line in slugs, whereas granular products are pushed through the line as air percolates through the spaces between granules.

Once the type of conveying and product characteristics are known, the table below can be used to identify elbows that may be suitable for the application. These are the main products commercially available today, and they should be able to cover a wide range of typical requirements. CEP

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