Pinch It: Contamination-Free Fluid Management Using Pinch Valves

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Transferring fluids in health care applications can be a complicated procedure when trying to ensure there is no contamination from outside surfaces. Pinch valves offer a solution via a pinching mechanism that "pumps" the fluid through the tubing. This article examines the technology, offers considerations for selection, and highlights the types of tubing that are best suited for use.

Many medical applications require transferred fluid to be isolated from external contamination. In these situations, valve choice is critical to creating a contamination-free device. Isolation valves, which cause the transferred fluid to contact valve components, require cleaning and flushing. In contrast, pinch actuators, commonly referred to as "pinch valves," use disposable thermoplastic medical tubing that is easily replaced and threaded through the pinch valve's head assembly.

Pinch valves are available in a variety of sizes, actuation types (pneumatic or electric) and pinching mechanisms. There are a variety of important design and material considerations when selecting the type of pinch valve to use.

Considerations	Pneumatic	Electric
High Operating Force	Preferred. If space is limited, multi-power cylinders can be used.	Expensive and inefficient.
High Duty Cycles	Preferred. No overheating problems.	Requires a larger solenoid and heat dissipation.
Solenoid Types	N/A	For higher forces but short strokes, choose flat face armature. For lower forces but long strokes, choose cone face armature.
Energy Saving	N/A	Special pick and hold circuits pull the plunger in with a brief high current. Once the plunger is retracted, a low "hold" current

		maintains the position.
Suitable for Battery Operation	N/A	A low power solenoid with a magnetic latch can “pull” the plunger open. A permanent magnet can hold it open without power. This requires a reverse circuit to re-close.
Cost for Custom Applications	Development can be inexpensive due to flexibility and capabilities of pneumatics.	Development can be expensive due to solenoid sizing and power supply selection.
Pinch Valve Mechanism	To ensure the tube closes at the corners, designs should provide ample space for the tube to deform.	

Chart 1: Pinch Valve Actuation Type Considerations

Electric Versus Pneumatic Actuation

Engineering and operational tradeoffs often drive the selection of actuation type (Chart 1). For example, for fluids moving at high pressure and flow rates, a pinch valve with stronger closing force is required. Pneumatic pinch valves work at high operating forces, although they can also function at low pneumatic pressures. In general, pneumatic pinch valves provide more design freedom and fewer engineering considerations than electric pinch valves. However, a pneumatic compressor or an alternative compressed air source is required.

Electronic pinch valve

Increased tubing diameter requires the actuator to have a longer stroke length to completely pinch the tubing closed. This becomes a critical factor when comparing pneumatic and electric pinch valves. As the operating stroke length increases, so does the size of the solenoid needed to provide the necessary closing force. Larger solenoids increase power consumption and the need to disperse additional generated heat.

The need to maintain a normally open or closed “fail safe” position also differentiates pneumatic and electric pinch valves. For electric actuators, holding the pinch valve in a powered position (either open or closed) can considerably increase power consumption and heat generation. A latching valve can address this issue. Latching valves include a circuit that activates a “magnetic latch,” which holds the valve in the desired open or closed position, and then shifts electricity to the solenoid. In the latched position the valve is held in place—either open or closed—and the power to the solenoid is shut off so that it does not overheat and burn out. Then a separate circuit is activated to release the latched position.

Solenoid power and size requirements are affected by the required duty cycle (cycle rate and typical on/off time). Generally, a high duty cycle (the solenoid opening and closing at a high frequency) increases power consumption and generates more heat.

	Silicone	**Medical PVC**	**Polyurethane**
Flex Resistance	Excellent	Good	Excellent
Temperature Range	Excellent	Good	Excellent
Strength	Good	Good	Excellent
Chemical Resistance	Good	Excellent	Good
Flow Characteristics	Good	Excellent	Good
Durometer Range	Good	Excellent	Excellent
Sterilization	Excellent	Excellent	Excellent

Chart 2: Medical Tubing Characteristics

Medical Tubing

Properties of elastomeric tubing (Chart 2), such as its durometer (flexibility) and chemical resistance, impact both the demands of the pinch valve, as well as the sterilization method utilized. Exposure to lower temperatures can also stiffen some medical grade tubing, requiring a pinch valve with higher closing force to completely pinch the tubing closed.

Pneumatic pinch valve

Silicone tubing remains extremely pliable and elastic across a wide variation in temperature. Standard for medical applications, silicone tubing meets most requirements for cleanliness and non-toxicity.

Polyurethane tubing also remains flexible across a wide range of temperatures. It is flexible, tough tubing that is available in a wide variety of durometers. It has excellent resistance to “flex fatigue” and returns to its original dimension upon release.

Medical polyvinyl-chloride (PVC) tubing is available in a variety of durometers. Its smooth surface maximizes flow and prevents sediment accumulation. It also withstands repeated sterilization, should this unique characteristic be beneficial to the application.

Conclusion
A pinch valve is an excellent solution to ensure sanitation and ease of changeover between procedures to ensure contamination-free fluid management. However,

Pinch valve design complete with the cylinder, plunger, and back stop. Bimba can design a custom pinch valve that will suit custom applications as well.

medical equipment design engineers need to consider many variables to ensure success.

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