Using Automated Pinch Valves in BioProcess Operations[1]

Background

Automated pinch valves represent a possible alternative to automated diaphragm valves in processes where flexible tubing is used (rather than rigid piping). These valves are designed to pinch tubing closed in one position and allow fluid through in the other (Photo 1 and 2).

PHOTO 1. Pneumatic Pinch Valve
(www.acroassociates.com)

PHOTO 2. Electric Pinch Valve
(http://www.biochemfluidics.com)

They are typically available in "normally open" or "normally closed" configurations. Pinch valves are also manufactured in two-way valve configurations. Multiple two-way valves can be used together to replace multiway, multiport diaphragm valves. Because there is no contact between valve and process fluid, pinch valves can be used in place of a diaphragm valve to eliminate the need for valve cleaning, disassembly for diaphragm replacement, and parts tracking. Process tubing is easily inserted into a pinch valve during setup. If the valve is in a normally closed position, the method of insertion varies. Some models require tubing to be stretched slightly as it slides into the closed valve. Others require that the valve be opened manually to allow for tubing insertion. Either procedure takes a matter of seconds. Valve sizes should be based on the size of tubing used. To operate properly, tubing's inner diameter (ID) and wall thickness should match with an appropriate valve so it both opens and closes optimally. The tubing's outer diameter may determine the required valve size, and its wall thickness may determine the default valve positions. Although a wide range of tubing types are compatible with pinch valves, compatibility requirements should be determined to ensure that tubing–valve interactions can meet process requirements. Silicone rubber tubing works generally well because when a valve is closed and then opened again, such tubing readily opens up. This has been the case even after thousands of open– close cycles. Several types of tubing are classified as thermoplastic elastomers (TPEs). TPEs may start to deform after repeated openings and closings, so compatibility with a process should be determined. However, some processes do not require repeated valve cycling. One other consideration is that if a valve remains closed with tubing inserted for an extended period of time, that tubing should not "stick" closed when the valve is ultimately actuated to open. This may be affected by the type of process liquid involved. Most bioprocess applications do not

involve such extended time frames in which tubing would stick together. If a process is extended, then valves are typically actuated more frequently than would cause a problem. Integration of automated pinch valves into process hardware and control systems must be evaluated before a choice is made. Valves come with electronic or pneumatic actuation, and the best choice depends on different factors. An electric valve has an on-board solenoid and can be wired directly; pneumatic valves require air pressure for their actuation through triggering of solenoid valves located elsewhere. For certain applications, an electric valve may be a "simpler" solution because it requires no instrument air or external solenoid valve. However, with an instrument cabinet and pneumatically actuated diaphragm valves in place, using pneumatic valves may be favorable. Both types of valves require appropriate mounting and/or housings. Also, pneumatic valves can handle larger tubing (up to 1-in. OD), which precludes the use of electric valves. One other consideration is process pressure. Obviously, limitations exist for all flexible tubing, but pneumatic valves generally resist opening when they are closed and exposed to higher pressures. Table 1 evaluates valves according to the considerations listed above.

Table 1: Points to consider for automated pinch valves

Valve Type	Process Compatibility	Performance	Control System Integration	Sterilization Capability
Diaphragm	Wide range	Excellent for many applications	Pneumatically driven by control system solenoid	Traditionally by autoclave or steam-in-place
Electric pinch	Requires compatible tubing Low pressure Tubing size limitations	Excellent if tubing is used and qualified for application	Actuated directly by electric signal (available for voltages of 12 and 24) Appropriate mounting or housing required	Not applicable; only the tubing requires sterilization.
Pneumatic pinch	Requires compatible tubing Pressure can be higher than for electric valves Up to 1-in. o.d.	Excellent if tubing is used and qualified for application	Pneumatically driven by control system solenoid Appropriate mounting or housing required	Not applicable; only the tubing requires sterilization.

Integration of the Valves to a Process

Once the proper valve is selected, functionally, the valves themselves are rather simple devices- they open and close to pinch the tube. They are typically activated by a relay external to the valve and a relay acts like a light switch- when the relay is closed it sends power to valve (or a relay-activated solenoid sends air to the valve) so the valve switches and when the relay is open, the valve is in it normal state. When you order a valve, you specify it as normally open or normally closed. An important consideration about selecting a normally open or normally closed valve is what happens if there is a power failure. Relays typically open when the power fails so if this is the case, the valve will go to its normal state if there is a power failure.

PendoTECH can offer assistance in process design of pinch valve(s) integrated to a process. This includes assistance with interaction with valve manufacturer, with valve selection, and design of hardware to mount and control the valves and the interface with a control system. Part of the design process includes mounting them with connectors and optional LEDs that indicate the valves are energized. Most valve manufacturers offer position feedback sensors that give an output signal to confirm a valve has physically

moved when given an actuation signal. Enclosure options include off the shelf ABS plastic enclosures on customized stainless steel enclosures (Figure 1).

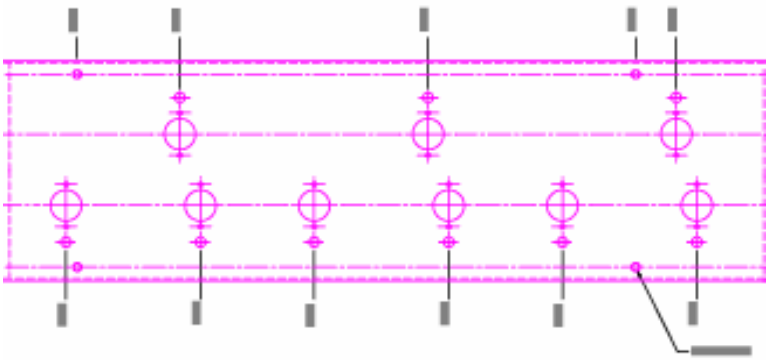

FIGURE 1. Drawing of Custom Designed Stainless Steel Pinch Valve Box with LEDs

The valves can be controlled by a customer's control system or an off-the-shelf device such as a PendoTECH PresssureMAT that has output alarm relays that are switched based on high or low user entered setpoints. PendoTECH can also design a custom control system that can interface and control other devices including pumps, scales, pressure sensors and much more. The pinch valve devices can be tested independently of a controlling system to ensure proper functioning when they are interfaced together. Samples of device design and built by PendoTECH are shown in Figures 2 to 6.

FIGURE 2. Normally Closed Electric Pinch Valves Mounted in a Stainless Steel Box with LED indicators

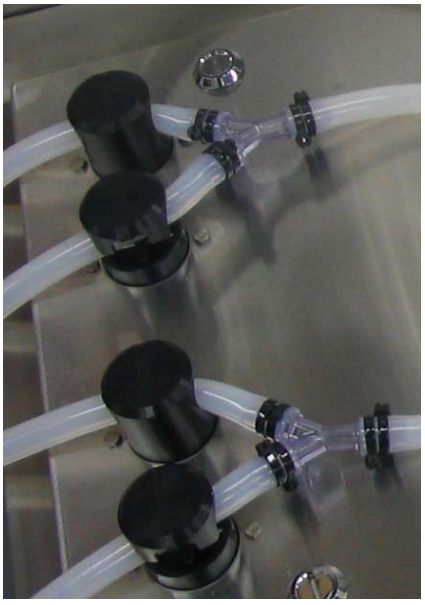

FIGURE 3. Normally Closed Pneumatic Pinch Valves Mounted in a Stainless Steel Box

Figure 4. Two normally closed electric pinch valves with power supplied with wall plug and two connectors on rear for remote control of valve

Figure 5. One normally open electric pinch valve with power supplied via connector on rear for remote control of valve

Figure 6. One normally open pneumatic pinch valve with air inlet on box and power supplied to solenoid valve in the box via connector on rear for remote control of valve

1 Some information presented published in the follow article:
"Suitability of Selected Single-Use Process Monitoring and Control Technology" by Kevin J.R. Clark and Jim Furey
BioProcess International 4(6):S16-S20 (June 2006)