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What are the Differences Between Rocker, Diaphragm, and Pinch Isolation Valves?

These valves are commonly used in medical devices, but can be specified whenever designers want to keep a media being moved isolated and uncontaminated by the activation mechanism.

The NIV Series Media isolation Valves from Clippard are diaphragm or membrane types that are bidirectional and feature all-PTFE wetted areas, as well as the ability to operate in temperatures up to 158°F.

Engineers and designers who want to control flow without contaminating media such as blood, pharmaceuticals, reagents, or even water can specify isolation valves. There are three general types of isolation valves (so named for their ability to isolate media): rocker, diaphragm, and pinch valves. They are commonly used in many types of medical applications, including those that require precise, repeatable dispensing of media in analytical, diagnostic, and therapeutic equipment. Here's a quick look at the characteristics, differences, and advantages of these valves.

ISOLATION VALVE BASICS

Any of these three valves can be set up to separate the activation mechanisms from the media being moved. They can also be configured as simple two-way devices or as multi-port selector/diverters, and are typically used in applications where a simple on/off function is needed rather than the ability to gradually modulate flow.

There are two main types of "on/off" media isolation valves: the rocker and diaphragm varieties. Although not formally considered isolation valves, pinch valves meet the definition and can be used for the same purpose.

Here are a few key concepts that describe important characteristics of media isolation valves:

Dead volume: The volume inside the valve that cannot be flushed during normal operations. Minimizing or eliminating dead volume is essential in applications where cross-contamination is an issue, such as drawing diagnostic samples from several patients.

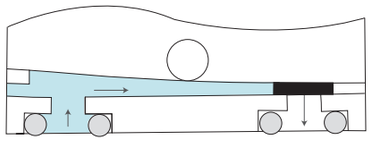
Internal volume: The volume trapped inside the valve assembly when the valve is closed.

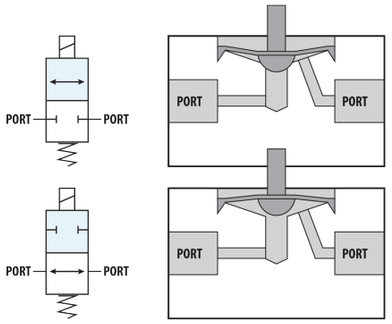
Swept volume: The volume of the flow path within the valve assembly. A streamlined flow path where swept volume is equal to internal volume means zero dead volume.

Wetted materials: Any material that contacts the media flowing through the valve.

ROCKER ISOLATION VALVES

A rocker isolation valve is a solenoid-operated device that uses a pivoting rocker mechanism to seal the valve seat and isolates the flow path *(see figure below)*. Rocker valves can be configured as simple two-way devices or as multi-port selector/diverters.





Rocker valves are generally smaller and more compact than diaphragm valves, making them well suited for applications with space limitations. Other benefits include low internal volumes and fast actuation times, along with relatively low costs. However, despite their low internal volume, rocker valves have more dead volume and are less well swept than diaphragm valves. This means they have more carryover (media left inside when valve closes), which can be problematic for certain applications as it increases the risk of cross-contamination. Another factor to consider is that rocker valves include elastomeric seals, giving them a shorter lifespan when used with corrosive chemicals and making them less chemically compatible than some diaphragm-style valves. Rocker valves are frequently used in industry for dispensing materials or to drive other larger valves.

DIAPHRAGM ISOLATION VALVES

A diaphragm isolation valve—also known as a "membrane valve"—is a solenoid-operated device that uses a diaphragm that extends and retracts to seal the valve seat and isolate the flow path. Like rocker valves, diaphragm valves can be configured as simple on/off two-way or three-way devices.

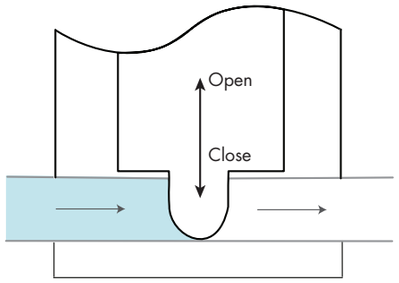
Compared to the rocker valves, diaphragm valves have much longer life, are better swept, and have much less dead volume—some as little as zero. Another benefit of these valves is that the diaphragm can be made from non-elastomer materials such as PTFE, which eliminates the need for seals and provides more chemical compatibility. This type of valve can be made of inert materials, including an entirely inert fluid path. This makes them ideal for applications involving corrosive media.

When selecting this type of isolation valve, it is important to consider the diaphragm material and the media that will be used. Some diaphragm valves use elastomeric membrane such as FKM or EPDM. These materials are highly flexible, which lets them tolerate small amounts of fine particles, but common chemicals such as methyl alcohol or ammonia can damage them. For chemotherapy treatments or other applications involving corrosive media, valves need more chemically resistant diaphragms made of materials such as PTFE.

When choosing a valve for use with corrosive media, it is important to ensure all wetted materials are inert. For the longest lifespan and lowest risk of cross-contamination, the flow path and all wetted areas of the valve should be constructed of an inert material compatible with the media that will be used.

PINCH VALVES

A pinch valve is an open valve, and closes the flow path by pinching a removable, disposable tube with a mechanical device that drops down to pinch the valve closed or lifts to open the valve. Pinch valves can be configured with single tubes as simple on/off two-way devices or with several tubes as multi-port selector/diverters.



Pinch valves may be operated by electricity, air pressure, or manual operation. The operation power for electrically actuated versions vary greatly according to the application and size of the valve. Most draw anywhere from 0.5 to 10 W AC or DC voltages, typically 12 or 24 V dc. They usually run off a medical system's internal power supply. Pneumatically-actuated valves are the preferred choice in explosive/hazardous environments where a shorted or overheated solenoid could become an ignition source. They also deliver more force, making them a good option for applications requiring firmer (higher-durometer) tubing. Another advantage is size. Pneumatically-piloted versions provide more force, so the valve can be scaled down to fit into smaller, more compact spaces.

For medical applications, pinch valves typically use medical-grade silicone tubing. If chemical compatibility is an issue, other materials may be used, provided they match the pinch mechanism's original durometer and O.D./I.D. specifications. For example, media containing chloroform, ether, and some common alcohols dissolve silicone tubing. Neoprene tubing, however, can be safely substituted.

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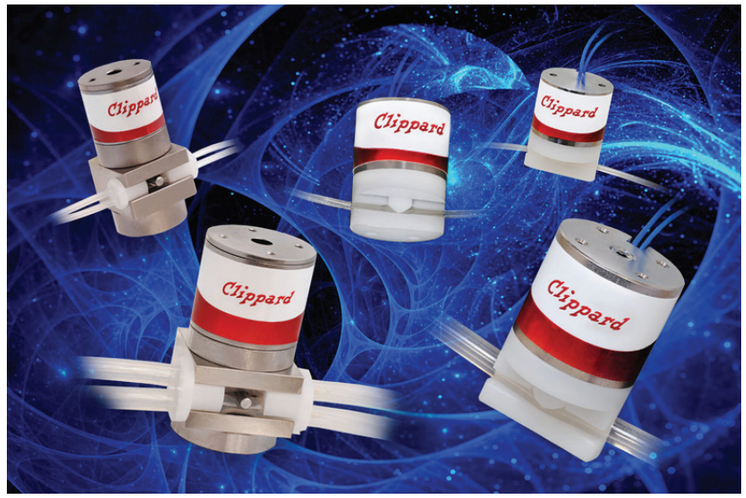

The NPV Series Miniature Pinch Valve from Clippard is available with one or two tubes. The single tube versions act as standard on/off two-way valves and can be normally-open or normally-closed. The two-tube version have a normally-open tube and a normally-closed tube, letting them function as three-way valves.

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By using the tubing as a gating element, pinch valves provide effective media isolation with zero internal or dead volume, without the need for complex mechanisms. This also lets pinch valves tolerate significant levels of suspended particulates in the media they carry. The biggest benefit pinch valves offer is that the tubing is easily replaced in case of failure or need for stringent cross-contamination control.

Pinch valves do have a few drawbacks. For example, they may require more electrical power or air pressure to actuate than diaphragm-style valves. They also tend to create an oval profile in the pinch tubing after repeated use, a phenomenon that reduces the flow for viscous fluids and makes the valve prone to clogs. If this is a potential problem, platinum-cured tubing is significantly less prone to this problem. Another factor to consider is that pinch tubes are quite soft (45 to 55 durometer) and cannot handle high-pressure media. The maximum allowable pressure is typically in the range of 20 to 30 psi for soft tubing.

Despite these issues, disposable tubing makes pinch valves easy to sterilize and an excellent choice for many medical applications such as intravenous systems, drug delivery, and dialysis equipment. They are also frequently used in patient care applications such as sampling, dosing, and infusion.

LIFETIME CONSIDERATIONS

Medical equipment is expected to operate reliably for long periods of time, so the operational lifetime of the components used becomes a critical design consideration. Like any other mechanisms, valves have finite lives, but cycle life varies significantly between valve types. For example, media isolation valves with elastomeric diaphragms are often rated for hundreds of millions of cycles, while those with non-elastomeric diaphragms typically carry lifetime ratings in the tens of millions of cycles. This is because the non-elastomeric materials, such as PTFE, are relatively soft and subject to accelerated wear.

Pinch valves suffer from wear and tear, but most of that occurs in the pinch tube itself, which is designed to be disposable. This means the operational life of a pinch valve is primarily limited by the lifetime of its pneumatic actuator or electrical solenoid, and they are often rated in the hundreds of millions or even billions of cycles. The lifetime of the pinch tube itself varies widely, according to the material it is made of. Neoprene tubing, for example, will start to deteriorate in several hundred thousand cycles while most silicone-based tubing survives for several million cycles.

Choosing the best valve for your application involves finding the best match between a design's requirements and the valve's characteristics. This is not always a straightforward process because so many variables are involved. For example, how much flow is needed, and what is the pressure of the media? Are there certain space limitations, specific power requirements, or a minimum required response time or lifespan? What type of media is being used, and what materials of construction are compatible with it? Does it contain particulates? How much of a concern is cross-contamination? Would disposable tubing be beneficial? The following table highlights some of the different characteristics of these types of valves and may be used as a guide for selecting the right type of valve to best meet the needs of a specific application. md

IF YOU have any questions regarding media isolation valves, please feel free to contact Clippard's Technical Support Team at tech@clippard.com.

COMPARING ISOLATION VALVES

Internal volume	Low	Minimal	Zero
Wetted materials	Low	Minimal	Zero
Lifespan (cycles)	I million	Hundreds of million with elastomeric diaphragms. Tens of millions with non-elastomeric diaphragms	Billions of cycles. Limited by tubing which is designed to be disposable.
Particulate tolerance	Tolerant	Elastomeric diaphragms tolerate small amounts of fine particulates. Non-elastomeric diaphragms are less tolerant	Highly tolerant
Chemical compatibility	Slightly compatible. Some are made of inert materials. Design included elastomeric seals	Highly compatible. Different diaphragm materials more compatible than others	Limited by tubing compatibility. Many varieties of tubing available.
Power Consumption	.2.5 W	1 to 15 W	Typically higher than other isolation valves. Electronically piloted valves: 2.5 to 12 W. Pneumatically piloted valves: 1 W for remote valve operation
Pressure (psi)	0 to 35	Vacuum to 100	Tubing cannot handle high-pressure media: 20 to 30 max
Actuation speed (msec)	1 t 20	10 to 100	5 to 25