VALVES & LEAK DETECTION

WITH Clippard

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The Basics

To understand hysteresis in some of its more complex states, it helps to first look at it in some of its simplest forms. Frictional hysteresis is relatively easy to understand because we can see—and sometimes feel—the results. Mechanical hysteresis is often referred to as “play” or “slop.” Think about a single knob water fixture that you turn clockwise to turn the water on. With this knob, you know that if you turn it directly to the 12:00 position without going too far, you get perfect water flow. However, this is an older faucet with a little “play” in the handle. If you go past 12:00, you end up needing to turn back to 11:00 to get that same perfect water flow. As you turn the faucet back, the “play” you are experiencing is a lag. This is an example of hysteresis.

HYSTERESIS AND HOW IT AFFECTS PROPORTIONAL VALVES *CONTINUED*

Proportional Valves & Hysteresis

Clippard defines hysteresis as the maximum difference in current required to achieve a set flow, relative to the maximum current. This can be expressed mathematically as:

$$H = \left(\frac{I_{UP} - I_{DOWN}}{I_{MAX}} \right) \times 100\%$$

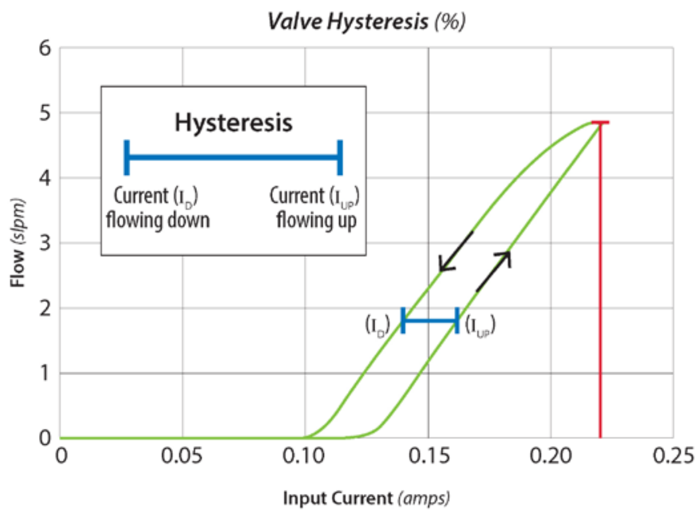
H = Hysteresis, I = Current *(I_{UP} flowing up, I_D flowing down)*

As it relates to proportional valves, hysteresis is the difference you see in flow when you go directly to a particular point, compared to when you go past that flow point and try to return back to it.

For example, consider a standard current driven proportional valve with a nominal hysteresis of 10%. If we apply 0.15 amps to achieve 1.0 l/min, then turn the current up to 0.2 amps for more flow, a nominal hysteresis of 10% means that when we come back down to 1.0 l/min, we would need to be about 10% lower with our supplied current to reach the original flow rate.

The hysteresis we see in current driven proportional valves is primarily magnetic. When we supply current to the valve's coil, we are producing an electromagnetic field which forces the poppet to move. It takes a greater force to open the valve than it does to close the valve—it requires more current to open on the uphill side of the flow curve than it requires on the downhill side of the flow curve.

HYSTERESIS AND HOW IT AFFECTS PROPORTIONAL VALVES *CONTINUED*



The lowest hysteresis proportional valve Clippard offers is the SCPV series stepper-controlled proportional valve. This valve is driven by a miniature stepper motor which has zero magnetic hysteresis and a mere 2% (nominal) mechanical hysteresis. This is the result of small amounts of "play" in the actuator. Think of a basic needle valve that you would adjust with your fingers, then put a stepper motor on top. Clippard's SCPV stepper-controlled proportional valves have become very popular in systems without feedback, because they can be commanded to a predetermined step to achieve repeatable performance.

Minimizing Hysteresis in Applications

Getting to the lowest hysteresis possible is a challenge. When working with solenoid driven valves, many variables such as temperature, wear, and spring rates can affect the magnetic hysteresis. Ultimately, good control can be achieved as long as the valve performance is repeatable. Any valve with consistent performance can greatly reduce hunting—when the system overshoots and undershoots multiple times to get to a point—in closed loop systems.

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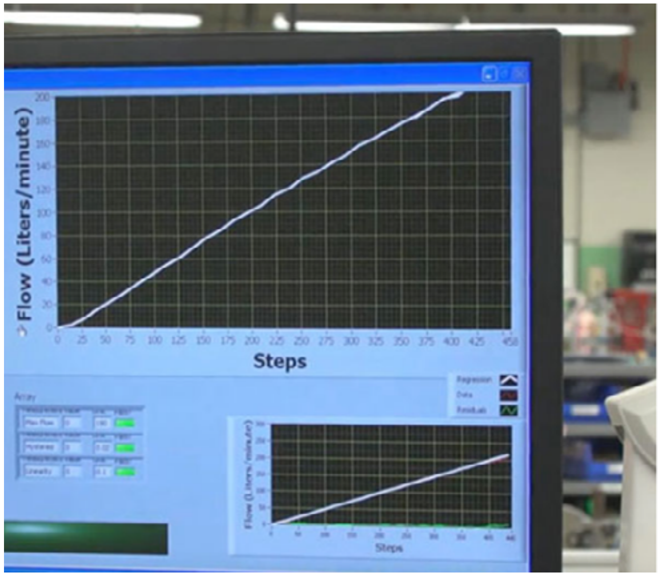

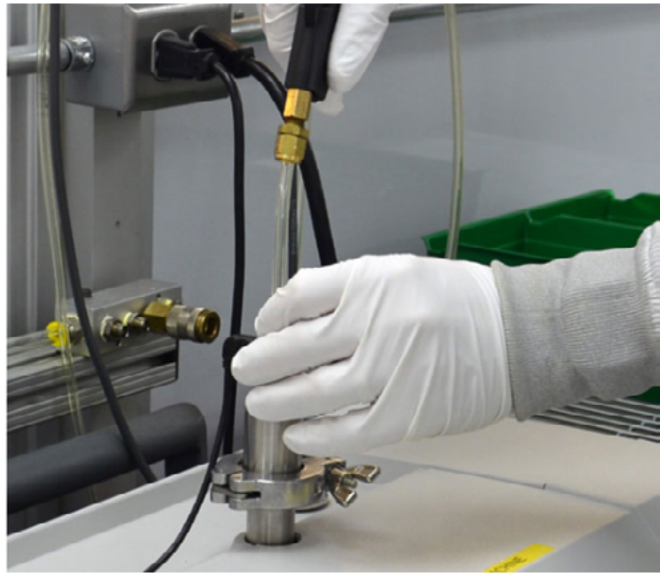

LEAK DETECTION METHODS

Understandably, manufacturers of leak decay testing equipment have especially high standards for the valves they use. In order for their testing equipment to function, it must hold a pressure or vacuum over a period of time, which is not possible if the valve leakage exceeds a certain amount. However, low leak valves are critical in other situations as well, such as for performing chemical analysis, controlling a flammable gas, or achieving a particular level of vacuum. This begs the question—how does Clippard ensure your leak requirements are met?

Leaks in a valve are characterized by a leak rate, which is often given as a volumetric flow rate at a standard temperature and pressure (e.g. standard cubic centimeters per minute; sccm). The standard conditions take away any ambiguity about how much gas (in terms of mass) is leaking out. In many cases, but not all, the standard pressure is 1 atm and the standard temperature is 20˚C. Since even units that have the “standard” word in them do not necessarily reference the same standard, other units have the standard pressure built right into them, such as atm-cc/s and Pa-m3/s. According to the NIST website, any volumetric flow rate that includes “atm” also assumes that the standard temperature is 0˚C.

There are many ways that valves can be checked for leaks. Clippard uses two of the most popular methods: pressure decay testing and helium leak detection.

LEAK DETECTION METHODS *CONTINUED*

Pressure Decay Testing

Pressure decay methods are an easy choice for many applications. Though decay testers can be quite sophisticated, they are fairly simple in theory. The integrity of the seals of a valve can be measured by how well the valve holds pressure in an otherwise closed volume. The tester pressurizes the volume with a gas, closes the volume, allows the pressure to stabilize, and then measures the volume pressure. After a specified amount of time it reads the pressure again. The amount of the pressure drop between the first reading and the second reading is an indication of the size of the leak in the VUT.

Pressure decay testing can very effectively determine whether a valve is bubble tight, but its sensitivity is limited. Increasing its sensitivity requires very long test times, and a pressure decay test does not by itself give customers a good indication of the actual leak rate of the valve. The relationship between leak rate and pressure decay depends on the size of the volume under test and the length of time between the two pressure readings. To overcome these limitations, Clippard utilizes helium leak detection.

Helium Leak Detection

A helium leak detector uses a mass spectrometer that is calibrated to detect helium ions in a very deep vacuum. The valve-under-test (VUT) is connected by fixturing to the test port of the detector, and the detector is then pumped down to the test vacuum level. Once the proper test vacuum has been achieved, the tester is zeroed to get rid of background helium levels. Then helium is sprayed around the VUT. If there is a detectable leak, the mass spectrometer quickly starts to see an increase of helium. The number of helium ions counted by the mass spectrometer is expressed as a leak rate of the VUT.

Contact Clippard for more information about our leak testing capabilities, or locate your local distributor.

AN OVERVIEW OF DIFFERENT TYPES OF ISOLATION VALVES

Controlling Flow Without Contaminating Media

To control flow without contaminating media such as blood, pharmaceuticals or reagents, a wide variety of medical devices and analytical equipment utilize media isolation valves. Isolation valves are devices that isolate a valve's actuation mechanism from the media being moved. They can be configured as simple 2-way devices or as multi-port selector/diverters, and are typically used in applications where a simple on/off function is required without the need to gradually modulate flow. These types of valves are well suited for many types of medical applications, including those that require precise, repeatable dispensing of media in analytical, diagnostic or therapeutic equipment.

What types of media isolation valves are available, and which is best suited for your requirements? There are two main types of "on/off" media isolation valves—rocker isolation valves and diaphragm isolation valves. Although not formally considered isolation valves, pinch valves meet the definition of a media isolated function.

AN OVERVIEW OF DIFFERENT TYPES OF ISOLATION VALVES *CONTINUED*

Rocker Style Isolation Valves

A rocker isolation valve is a solenoid-operated device that uses a rocker mechanism that pivots to seal the valve seat and isolate the flow path. Rocker isolation valves are generally smaller and more compact than diaphragm isolation valves, making them well suited for certain applications with specific space limitations. Some of the other benefits of rocker style isolation valves are that they can be relatively inexpensive, with low internal volume and fast actuation times. However, despite their low internal volume, rocker valves have more dead volume and are less well swept than diaphragm isolation valves. This causes them to have more carryover, which can be problematic for certain applications, as can an increased risk of cross contamination. Another factor to consider is that rocker valve designs include elastomeric seals, giving them a shorter lifespan and making them less chemically compatible than some diaphragm style 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 style valves, diaphragm isolation valves can also be configured as simple on/off 2-way or 3-way devices.

Compared to the rocker style, diaphragm style media isolation valves feature much longer life, are better swept and have much less dead volume—some as little as zero. Another benefit of this type of isolation valve is that the diaphragm design can be made from non-elastomer materials such as PTFE, which eliminates the need for seals, providing increased chemical compatibility. This type of isolation valve can be constructed from inert materials, including an entirely inert fluid path. This makes diaphragm style isolation valves 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 style isolation valves use an elastomeric membrane such as FKM or EPDM. The high flexibility of these types of materials allows them to tolerate small amounts of fine particles, but common chemicals such as methyl alcohol or

AN OVERVIEW OF DIFFERENT TYPES OF ISOLATION VALVES *CONTINUED*

ammonia can damage these types of diaphragm membranes. For chemotherapy treatments or other applications that involve corrosive media, specially designed non-elastomeric diaphragm isolation valves are available with more robust membrane materials, such as PTFE. When choosing a valve for use with corrosive media, it is important to identify that 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 that is compatible with the media that will be used.

Pinch Valves

A pinch valve is a device that opens and closes the flow path by pinching a removable, disposable tube. Although not formally considered isolation valves, pinch valves perform an identical function by isolating the valve mechanism from the media through the use of this disposable tubing. Similar to isolation valves, pinch valves can be configured with single tubes as simple on/off 2-way devices or with multiple tubes as multi-port selector/diverters.

Pinch valves may be operated by electricity, air pressure, or manual operation. The operation power of electrically-actuated pinch valves varies greatly according to the application and size of the valve. Most draw anywhere from 0.5 to 10 watts AC or DC at a range of voltages—typically 12 or 24 VDC—and can usually run off a medical system's internal power supply. Pneumatically actuated pinch valves are the preferred choice in explosive/hazardous environments where a shorted or overheated solenoid could become an ignition source. They are also able to deliver more force, making them a good option for applications that require the use of firmer (higher durometer) tubing. Another advantage is size—since pneumatically piloted units are able to provide more force, the size 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 specifications.

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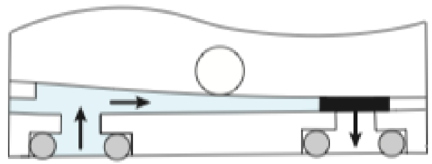
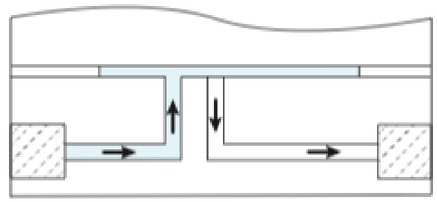
AN OVERVIEW OF DIFFERENT TYPES OF ISOLATION VALVES *CONTINUED*

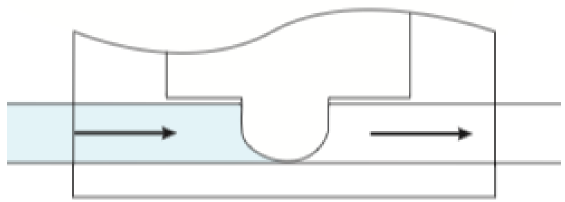
Rocker style isolation valve



Diaphragm style isolation valve



Pinch valve



Pinch valves also have a few drawbacks. For example, they may require more electrical power or air pressure to actuate than a diaphragm-style valve. They also tend to create an oval profile in the pinch tubing after repeated use, a phenomenon that can reduce the flow of viscous fluids and make the valve prone to clogs. The sterility offered by disposable tubing makes pinch valves an excellent choice for many medical applications such as intravenous systems, drug delivery, and dialysis instrumentation. 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 its components becomes an important design consideration. Like any other mechanism, a valve has a finite lifetime, 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 10's of millions of cycles. This is because the non-elastomeric materials (i.e. PTFE) are relatively soft and subject to accelerated wear.

Pinch valves also suffer from wear and tear, but most of that occurs in the pinch tube itself, which is designed to be disposable. This means that the operational life of a pinch valve is primarily limited by the lifetime of its pneumatic actuator or electrical solenoid—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 can survive for several million cycles.

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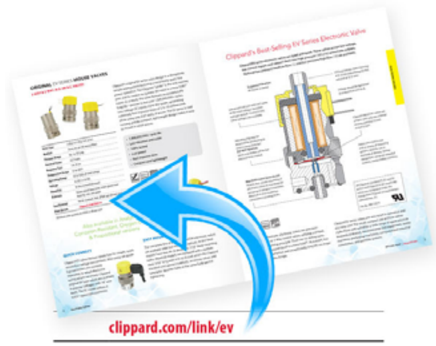

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