Hydraulics & Pneumatics

Proportional valve design meets control system challenges

Clippard Instrument Laboratory, long a pioneer in the miniature pneumatic industry, has achieved a break-though in proportional valve technology with the introduction of the EVP series proportional valve. Since 1974, Clippard (clippard.com) has produced the EV series valve, said to combine simplicity of design, low power, fast operation and long life (applications have exceeded 3 billion cycles with a single valve), resulting in one of the most successful and reliable products in its 60+ year history.

The heart of the valve is the armature, which is the valve's only moving part. Dubbed the 'spider' because of its flexing 'legs,' it has contributed to make the EV valve both very reliable and versatile. This valve has been used in thousands of applications by OEMs with exacting requirements.

Now the spider has again provided the spark for a new product series for Clippard. By re-engineering the (now) conventional spider element, an engineering team at Clippard has created a valve which provides a variable output flow that is proportional to input current. The unique and patented design of the new proportional valve delivers an accurately positioned spider giving a precise, variable output flow. This provides the OEM design engineer what he needs to solve control system challenges for a wide variety of applications.

When considering the existing state of proportional control in analytical machines, mass flow controllers, and medical applications (especially non-invasive blood pressure monitoring, dialysis, and respirators), Clippard saw some challenges. Valves currently on the market can have a hysteresis as high as 15% that can wreak havoc in open- or closed-loop control systems. Valve-to-valve variation in the maximum flow can cause problems, as well. Lastly, the variation in gain that is typical with the current generation of valves can cause the design engineer the most headaches.

The gain of a proportional valve is the rate of flow change to valve input current. Differences in the gain of a given valve cause the performance envelope to be quite large, putting the burden on the OEM to make its equipment adapt to those weaknesses.

In order to improve all three of these characteristics, while still providing a good value, Clippard's redesign of the proven spider element and the sloped ramp that it acts upon needed to achieve a better result. As it tackled these challenges, one of the unique characteristics of the original EV valve, its factory-adjustable core, proved to have a decisive advantage over existing proportional valves.

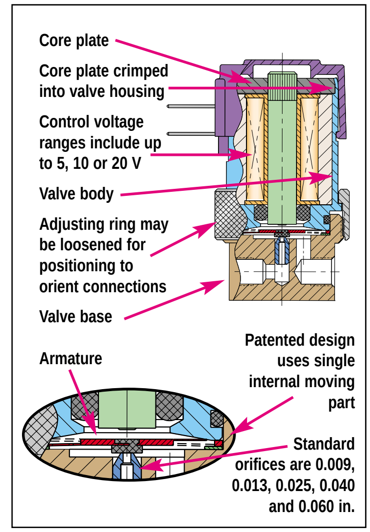
It gives Clippard the ability to adjust the magnetic field to compensate for the mechanical tolerance limitations with which all proportional valve manufacturers have had to contend. As a result, the Clippard proportional valve has an improved maximum flow variation - as little as ±10% - and also has more consistency and linearity of gain. These two improvements should prove to make the OEM design engineers job much easier, due to better controllability.

The main cause of varying gains from valve to valve is the mechanical and geometrical tolerances that occur in normal manufacturing processes. Most manufacturers use a chemically-etched or stamped flat spring to resist plunger or armature movement. The spring, in conjunction with the surface it makes contact with, is used to create the proportionality between flow rate and valve coil current. As electrical current is increased the armature is subjected to a magnetic field. The magnetic field creates a magnetic force on the armature that pulls on it. The flat spring resists this travel until the magnetic force on the armature equals the force that the flat spring subjects on the armature.

The flat spring is the critical component in maintaining consistent gains from valve to valve. But typical tolerances for flat springs can cause changes in spring rate. For example, the spring rate of flat springs is inversely proportional to the thickness of the material it is made of to the third power. Which means that if manufacturer's tolerances vary by 5% in thickness, a spring rate fluctuation of 35% could exist. Therefore, large swings in gains will exist when there is only slight variations in flat spring thickness.

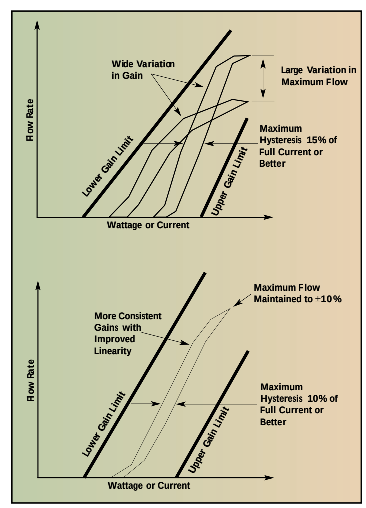
Clippard's unique design incorporates a low mass element, properly selected materials and virtually no friction. These design elements are combined to produce a valve that is highly responsive, has a long life and exhibits a hysteresis of less than 10%. This means a much improved platform for use in open- and closed- loop control systems.

Ventilators, anesthesia machines, non-invasive blood pressure monitoring, gas chromatograph equipment, and a host of other control applications are suitable for the Clippard valve. In addition, applications from paint delivery systems and flow controllers to semiconductor CMP and environmental analysis can use the EVP proportional valve. Technically speaking, this valve controls flow – but add a pressure sensor and comparator circuit, and you have an electronic pressure controller.



Sectional view of the EVP proportional valve: *By press fitting the core closer to the armature, Clippard has increased the magnetic field to create more pull on the armature. The result is a tolerance of ±10% of maximum flow or better.*

The EVP proportional valve is offered with standard and manifold mounting options, a variety of orifice sizes and control voltage ranges, and three difference electrical connector options.



Above: *Two typical valve performance curves of a competitor's valve. To compensate for the extreme variations of valve gains, the specification window has been made quite large. Since the gains from valve to valve vary, so does the maximum flow of the valve.* **Below:** *A typical Clippard proportional valve hysteresis curve. A relatively consistent linear gain over the entire flow range is much better than the typical "S" shaped gain offered in the market now.*