Valve Innovation Optimises Chromatography Process; Removing Dead Legs, Minimising Hold-Up Volumes & Increasing Yields

Brett Davies, DMA Europa Ltd, 2nd Floor, Snuff Mill Warehouse, Park Lane, Bewdley, Worcs. DY12 2EL.
Tel: 01299 405454 • E-mail: bd@dmaeurope.com

Helen Christopher, Burkert Fluid Control Systems, Brimscombe Port Business Park, Brimscombe, Stroud, GL5 2QQ.
Tel: 01453 731353 • E-mail: helen.christopher@burkert.com

There are a number of important considerations in the optimised design of a chromatography process; the selection of valves being not least amongst them. The importance of correct valve selection is evidenced by the benefits it provides. As well as delivering equipment and installation savings, optimised valve selection can eliminate all dead legs, meaning that sterility is easier to ensure and maintain. It can also mean faster flow shifts and reduced risk of cross contamination. In addition, the compact design of the latest single diaphragm valves, combined with manifold blocks, ensures minimal hold-up volumes, increasing product yields, with less media waste.

Typical challenges for valve solutions in chromatography:

Valve selection is usually a crucial discussion point amongst design engineers, with traditional solutions generally based around diaphragm valve technologies. These solutions make use of very closely welded cluster arrangements, with the shortest possible tangents and optimised positioning according to draining/cleaning requirements. However, even with optimised design, the requirement for minimised hold-up volumes in complete chromatography systems can often be compromised by complex valve clusters. This is because, the more valves needed, the more welds, pipe lengths, T-pieces that are required, and, ultimately, the more hold- up volume generated.

In addition, valve clusters can also militate against fast and accurate flow shift, which is essential for process efficiency. In downstream applications such as chromatography, the ability to shift quickly means higher yield capture, and more efficient batch control. If the accuracy of the flow shift is higher and reliable, then the relationship between concentrated product and the separation step can be controlled more closely. This will subsequently reduce product loss and have a positive impact on the return on investment of the installation.

A further major challenge with the clustering approach is that, in larger systems the complex arrangement of valves, as well as their physical individual size, can result in large and heavy clusters that have to be supported, and be easily accessible for maintenance. In addition, the larger the valves required, the more overall space is required, and when considering the need for fully drainable and cleanable systems, this is not ideal.

Such challenges which are closely associated with valve solutions in chromatography have led to technology and manufacturing advances, which have resulted in a new design based upon unique Robolux valves and custom manufactured stainless steel valve blocks. With this design, hold- up volume is eliminated by reducing - by half, or more - the number of valves, diaphragms, pipe fittings and welds required in a system.

The patented Robolux valves can be used on fixed or mobile separation units, and are designed for operation on general- purpose or multi- purpose systems in LP to MP (Low Pressure / Medium Pressure) chromatography applications. The valves are downstream items located immediately after the separation process, where they are used as efficient diverters for the separated media on the column outlets/system outlets. They are also used on agent distribution lines when adding agents to the columns/system.

Based on diaphragm valve technology, this generation of valves combines' independent dual process switching functions or "2 seats" in a single body with a single diaphragm and single actuator. The actuator has independent pistons – one for each seat, offering a compactly- designed

multi-port valve requiring about 40 percent less space than traditional valve manifolds using conventional diaphragm valves. The image adjacent shows a transparent view of a pneumatic operator. The actuator is made from aluminium and is finished in white with an epoxy coating. Each chamber has a pilot air connection and an exhaust port. For position indication it is possible to fit two proximity switches to each side – one for high (open indication) and one for low (closed indication). That means in total you can have four switches per actuator. Since less material is used in the valve bodies, they can be heated more quickly to the sterilization temperature required to destroy micro-organisms. A low internal volume, and elimination of dead space, also supports faster cleaning and, of course, means better process efficiency and higher product yield from the process.

Continuing the benefit of minimum space requirement, the overall number of valves, T-piece, weld joints and pipe runs are greatly reduced. The result is an optimized space footprint that enhances process efficiency, reduces installation and maintenance costs and minimizes downtime.

The Robolux Valve makes use of a body (typically machined from 316L stainless steel) which incorporates two traditional weirs located next to each other. On top of this body sits a diaphragm; often manufactured of materials like EPDM, PTFE or silicone the diaphragm is completely moulded and does not have any metal parts. This is an advantage for diaphragm lifecycle.

Cleanability

The cleanability of a pipe system is influenced by dead space volumes and the application of the xD rule. Currently, the industry is satisfied with the 3D rule. Its consistent application ensures sufficient flushing for many processes. The dead legs will be completely flushed and cleaned only if the length of the dead legs is less than three times the diameter of the main pipe.

It is usually not possible to consistently implement the 3D rule when arranging complex configurations with conventional valves; the goal of any plant operator and planning engineer is to remain well below the requirements of this rule. The ideal solution is to achieve the 1D rule now, and the Robolux valve solutions are capable of this. The internal volume of the valves and/or valve manifolds is significantly smaller than with conventional valve solutions and there is no dead volume inside them.

If four conventional DN25 diaphragm valves are welded in a typical steam cross configuration this results in an internal volume of 90 millilitres held in the pipe section between the 4 valve seats. If this solution is enhanced by using a standard valve block, the internal volume can be reduced to 50 millilitres. Finally, if the standard valve block is replaced with a Robolux valve, the total inner space volume is only 22 millilitres. These valves therefore minimize not only the required installation space, but also the amount of flushing agent needed, and time – with significantly improved cleanability.

Prevention of corrosion

The cleanability of the pipes and valve manifolds is also extremely important for another reason: Improper flow through the body may result in corrosion, which is a serious problem in production facilities. The cleaning or replacement of the corroded equipment entails great expense and lengthy downtimes.

The use of Robolux valve interfaces can effectively help prevent corrosion. This is confirmed by means of riboflavin or uranine tests in Burkert's in-house test facility that allows simulation of actual operating conditions.

Process reliability and availability

Valve interfaces must meet high standards to guarantee reliable processes and yet remain flexible for different applications. Robolux valves can provide a "double block and bleed function" to prevent steam used for sterilization of the parallel line from contaminating the product and vice versa; it is achieved by using a relief valve in between the 2 seats. Multi-port valve bodies genuinely enable the effective implementation of many complex applications. For example, parallel operation is possible with the use of a Robolux DFP (Double Flow Path) interface which increases overall availability of the plant and saves production time.

Multi-port valves can also act as a reliable sterile barrier; a solution using two actuators and 2 diaphragms provides the function of a steam barrier with 4 connections and 4 seats that replaces four conventional valves with their single actuators, and the corresponding piping and connecting elements. In this way, Robolux multiport valves contribute significantly to cost reduction in hygienic processes.