

Treating gases safely and cost effectively

Factors that must be taken into account when choosing valves for PSA systems

Pressure swing adsorption (PSA) is an established method for separating and purifying gases. This technology is incredibly versatile and is used across a wide range of technical applications. While PSA systems are commonly used in the chemical industry for producing industrial gases, they have been in high demand worldwide for the production of medical oxygen during peaks in the coronavirus pandemic. They also play an important role in the production of green hydrogen for decarbonization in the energy sector. After being produced by electrolysis or steam reforming, this sought-after gas is often purified using PSA systems.

The applications are varied but the requirements remain the same: PSA systems must be reliable and cost effective to run. To meet these requirements, GEMÜ has established itself as a single-source supplier of suitable valves, measurement and control systems for the system equipment.

PSA systems function on the basis of selective adsorption with periodic pressure swings. In a typical PSA system, molecular sieves are added to a pressure tank, where they form the adsorption bed. The gas mixture that needs to be purified is then flushed through the adsorption bed under pressure. With this method, the more readily adsorbable gas components accumulate on the surface of the adsorbent material, while the components that are less readily adsorbed or cannot be adsorbed at all pass through the packed bed. The higher the pressure, the greater the adsorption. For this reason, the process is normally carried out at approximately 7–8 bar.

The adsorbent material continues to trap readily adsorbable gas components until a state of equilibrium is reached, at which point it has reached its maximum adsorption capacity. In order to perform a new gas separation cycle, the adsorbent material needs to be regenerated. This step is known as "desorption". All that is needed for the desorption stage is to lower the pressure and to flush purified gas through the bed. When extracting nitrogen, compressed, dried, filtered air, for example, flows into the adsorption tank. As a result, oxygen is selectively adsorbed by the molecular sieves. Purified nitrogen flows out. The second tank is regenerated in parallel to this, which means venting it and flushing it out.

In order to operate a PSA system continuously, two or more adsorption tanks are operated in alternating fashion, switching between adsorption and desorption cycles. By transferring the excess pressure between the parallel adsorption tanks, the system can be operated continuously and significant energy savings can be made.

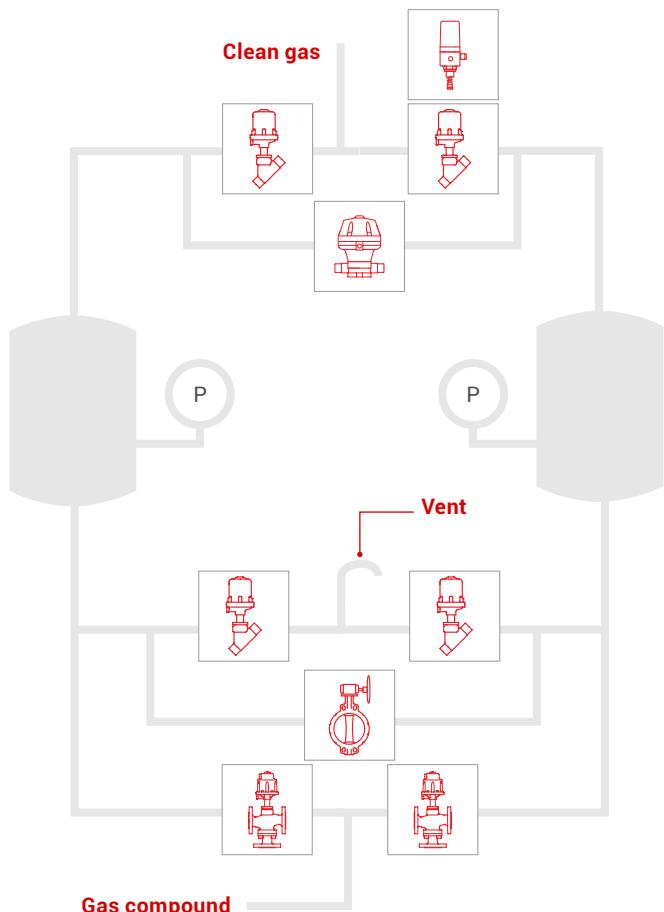


Figure 1: Diagram of a PSA system with shut-off and control elements

The system equipment depends on the process parameters

The requirements are strict when it comes to the purity of gas produced by pressure swing adsorption. Manufacturers generally guarantee high or even ultra pure gas quality between 93 and 99.999%. The efficiency and reliability of a PSA system hinges on the quality of the process equipment.

For valves and measurement and control systems, GEMÜ offers a wide range of solutions that are precisely tailored to the requirements of PSA systems. Their design is strongly influenced by process parameters such as the medium, the operating pressure or other specific conditions such as the bidirectional flow between tanks that are being operated in parallel. A design that saves space is also an advantage if plant manufacturers want to maintain a competitive edge.

Care when dealing with corrosive media

A wide variety of media such as air, nitrogen, oxygen, hydrogen, methane and carbon dioxide are used in PSA systems, depending on the application in question. While air, as a chemically neutral medium, does not present any particular challenges when it comes to choosing valves for PSA systems, material resistance and rugged, reliable valve design must be a focal point at least when choosing components for handling flammable media such as corrosive oxygen.

Oxygen is considered a critical working medium, since many materials burn intensely and quickly with compressed or pure oxygen. For this reason, special care must be taken with PSA systems in which gaseous oxygen is used. In Germany, the Federal Institute for Materials Research and Testing (Bundesanstalt für Materialforschung und -prüfung – BAM) must test and evaluate non-metal materials for operation with oxygen or gas mixtures containing more than 25% oxygen.

To ensure that systems run safely and reliably, GEMÜ takes great pains to ensure that suitable materials are used. In the case of oxygen applications, this primarily concerns auxiliary and seal materials. This is why, for example, all sealing materials in GEMÜ valves that are suitable for applications involving gaseous oxygen have been tested and approved by the BAM.

Efficient pressure and flow measurement for cost-effective operation

For a PSA system to operate efficiently, precise pressure and flow measurement is required. Inefficient pressure swinging results in reduced performance and increased operating costs, and may even result in the adsorption beds being damaged. To avoid this situation, GEMÜ offers a wide range of measuring equipment. The GEMÜ 3140 pressure sensor is capable of taking precise measurements across a wide pressure range, for example. For applications involving chemically corrosive media, the media-wetted parts are available with a PVDF coating.

For supplying media, for pressure swinging, for flushing and for venting, precise flow control is required. Globe valves are often used for this purpose. This is because of their compatibility with gases under moderate pressure and their reliability and durability over a high number of switching cycles. Diaphragm valves, on the other hand, enable bidirectional flow for pressure swinging because they can be installed in any position.

Due to the strict safety or quality requirements, monitoring the valves installed in PSA systems is essential for all the automated processes that take place in the systems. Reliable position indicators and positioners with PLC units are used to control and regulate the system during the individual process steps. For pneumatic actuators, position and process controllers are fitted and tested at the GEMÜ factory, and then delivered as a complete system. This minimizes the amount of work involved with regard to logistics and installing the system on site, and simplifies the documentation process.

Compact units for a competitive edge

Alongside process conditions, business and economic considerations also play an important role in producing PSA systems competitively.

Regardless of the gas that needs to be produced or purified, all PSA systems have one thing in common: Media must be conducted quickly and precisely to enable cycles to be repeated in rapid succession.

For the valves in the system, this means that high capacity utilization must be combined with reliable performance; they must also require minimal maintenance.



Figure 2: GEMÜ 553 distribution valve for an efficient use of space



Figure 3: With the GEMÜ P500 (left) or P600 (right) multi-port valve blocks, plant manufacturers save space and minimize potential leaks

If, as is common, the system is designed to be on a skid or is designed as a container solution, the space requirements can be minimized through the use of innovative block or modular solutions for the valves and measuring equipment; this contrasts with conventional system designs, in which the individual components take up a significant amount of valuable space overall. Plant manufacturers not only have to connect the valves, measurement systems, positioning elements and positioners to the supply lines, but they also have to install things like individual sections of pipe, fittings and seals between all these components.

Plant manufacturers that are able to save their customers money in the form of compact, easy-to-maintain systems are ahead of the game.

Using multi-port valve blocks like the GEMÜ P600 or other modular distribution systems like the GEMÜ 553, which consists of individual modules that can be adapted directly, plant manufacturers can not only significantly reduce the amount of space required by directly connecting the individual system components; they can also save on piping.

Special multi-port valve blocks also minimize potential leaks because GEMÜ makes these from a single piece.

The ease with which the individual modules can be securely connected means that installation takes next to no time. System operators also benefit, since maintenance work is quicker and easier to carry out. Additionally, GEMÜ's flexible modular system allows further units to be retrofitted as needed with very little effort.

Conclusion

With their proven technique, PSA systems are a widely used technology for treating and purifying a whole variety of different gases, solving a multitude of different problems. They must be capable of meeting the high demands placed on the end product, as well as being both reliable and cost effective, irrespective of whether they are being used for industrial applications or for the chemical, medical or energy sector. With tailor-made process equipment, all this is possible.