

Double-eccentric butterfly valve for high demands in gas separation processes (e.g. PSA)

AMJED SLIM, NADINE WETZSTEIN, MARCUS MIERTZ, JÖRG KIESBAUER

In the field of industrial gas purification and gas separation processes, pressure swing adsorption (PSA) has developed rapidly over the past few years and has become a true alternative to other thermal separation processes, such as adsorption or membrane separation. The required high degree of purity and amount of gas recovered strongly depend on the industrial valves used in the corresponding plants. The special double-eccentric control and shut-off butterfly valve introduced in this article was developed to meet these high demands.

PRESSURE SWING ADSORPTION

PSA plants are used worldwide, for example to recover hydrogen from various hydrogen-containing gases, to separate gaseous oxygen from ambient air, or to upgrade biogas into biomethane.

The long-term objective is to replace fossil fuels, such as crude oil, coal, and natural gas.

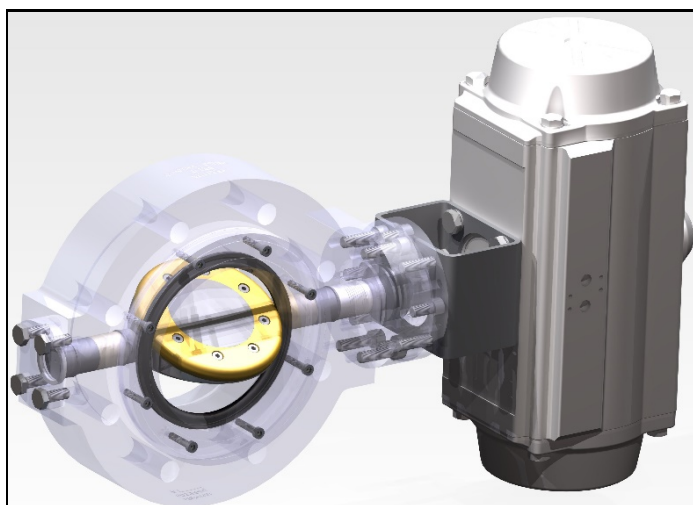


Fig. 1: PFEIFFER Type 14p PSA Control and Shut-off Butterfly Valve in heavy-duty design

The number of adsorbent beds, adsorption pressure, and purity of the recovered gas vary in PSA plants depending on the field of application.

The main advantage of pressure swing adsorption is the product purity that can be achieved: up to 99.99 vol% hydrogen, more than 96 vol% biogas, and up to 94 vol% oxygen.

To achieve a high degree of purity and to recover the greatest amount possible of product gas, high demands are placed on the control and shut-off butterfly valves used:

- Tight bi-directional shut-off (at least leakage' class VI according to IEC 60534-4:2006)
- Short opening and closing times (≤ 1 s)
- High level of operational reliability guaranteed for up to one million cycles

FEATURES OF THE PFEIFFER BUTTERFLY VALVE FOR PSA APPLICATIONS

The short switching times, large number of cycles, and the high operating pressures in a PSA plant (up to 30 bar depending on the PSA process used) require a solid valve construction.

To meet these demands, the heavy-duty design of the PFEIFFER Type 14p PSA Valve is particularly rugged with a sturdy built valve body and double-eccentric butterfly disk (Fig. 1). The double eccentricity guarantees low-friction actuation and provides the conditions for short opening and closing times of the PSA butterfly valve (Table 1).

To minimize the coefficients of friction at the seat and the resulting wear, a special elastomer seat ring in combination with a specially coated disk ring is used in the Type 14p - PSA Butterfly valve.

The seat and disk seal was optimized to achieve a tight shut-off over a long service life and to reduce the breakaway and closing torques.

The specification for tight bi-directional shut-off for gases was verified in endurance tests (see below).

The proven PFEIFFER design with a V-ring packing loaded by disk spring together with an upstream primary seal is used to seal the shaft and guarantee the sealing ability to the atmosphere despite of the large number of cycles.

This maintenance-friendly packing, which meets strict emission requirements (TA Luft), is installed in over 30,000 valves annually at PFEIFFER.

Additionally, the actuator and the corresponding accessories play an important role in achieving the switching frequency as well as opening and closing times under one second.

THE MATCHING PFEIFFER ROTARY ACTUATOR: RELIABLE AND FAST ACTING

The PFEIFFER Type 31a Rotary Actuator has been systematically tuned to handle high-performance tasks. All technical features have been optimized to make it a reliable, versatile actuator, even for PSA applications.

Particularly large air ducts allow the standard version of the Type 31a Rotary Actuator to achieve very fast stroking speeds. The improved lubrication at the piston means that the actuator continues to position the valve accurately far beyond one million cycles.

An improved surface finish of the actuator housing ensured that the actuator easily passed the salt spray test, which lasted 1,500 hours.

A reliable actuator unit with excellent control performance is achieved in combination with a SAMSON positioner and volume booster, even though only standard devices are used (Fig. 2).



Fig. 2: Typical instrumentation for a butterfly valve for PSA applications

ENDURANCE TEST: ONE MILLION CYCLES

The service life of the Type 14p Double-eccentric Butterfly valve for PSA applications was tested in cycles at SAMSON in Frankfurt am Main, Germany, to verify the seat leakage and fugitive emissions. The objective was to accumulate at least one million cycles without replacing any parts subject to wear.

The tested unit has the following features:

- Valve size: NPS 6
- Pressure rating: Class 300
- Face-to-face dimension: 59 mm
- Body and disk: Stainless steel
- Actuator: PFEIFFER Type 31a SRP900 3.5 bar
- Positioner: SAMSON Type 3730
- Volume booster: SAMSON Type 3755
- Actuating time: ≤ 1 s

Valve size	DN 80/NPS 3 to DN 400/NPS 16
Pressure rating	PN 10 to PN 40 and ANSI Class 150, Class 300
Body	Steel (1.0619/A216 WCB) or Stainless steel (1.4408/A351 CF8M)
Temperature range	-20 °C to 180 °C (-4 °F to +356 °F)
Face-to-face dimensions	Standard according to EN 558 R16 and API 609, special FTF dimensions on customer request

Table 1: Technical data

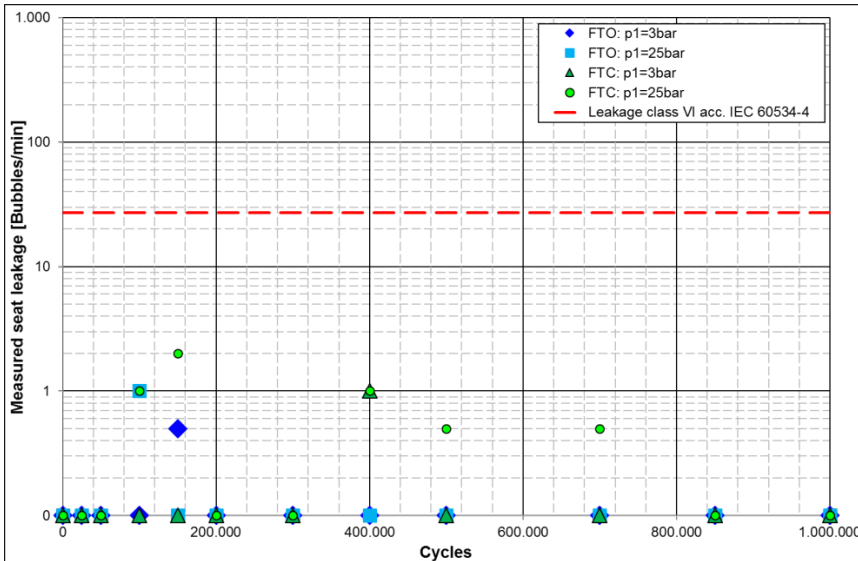


Fig 3: Results of the seat leakage tests

During the load change, 10 bar(a) air pressure were applied to the inlet of the Type 14p - PSA Butterfly valve. The outlet was exposed to the atmospheric pressure of $p_2 = 1 \text{ bar(a)}$.

An actuator with appropriate hook-up was mounted onto the valve to achieve the fast opening and closing times of under one second required for PSA applications.

The seat leakage was tested in cycles according to IEC60534-4: 2006 in the FTO and FTC directions of flow with air at various test pressures.

The limits of the highest leakage class VI were constantly kept over one million cycles at test pressures of up to $p_1 = 25 \text{ bar}$. Furthermore, the valve



Fig. 4: PSA butterfly valve based on the segmented ball design (PFEIFFER Type 16p)

was bubble tight over a long service life and met the leakage rate A requirements according to DIN EN 12266 (Fig. 3).

In addition to seat leakage, the packing was subjected to cyclic testing with up to one million cycles. Absolute tightness was achieved in tests performed with air at upstream pressures (p_1) up to 25 bar.

The PFEIFFER V-ring packing loaded by disk springs used together with an upstream primary seal for PSA applications was bubble tight.

The butterfly valve and actuator were dismantled and inspected after completion of the endurance test.

The design benefits of the Type 14p PSA Butterfly valve and Type 31a Actuator were confirmed during this

inspection, which showed the excellent state of the parts subject to wear after one million cycles.

The positive findings concerning the actuator clearly exceeded the requirements given in DIN EN 15714-3, which stipulates that pneumatic piston actuators with a torque up to 1000 Nm must be able to perform at least 500,000 cycles without wear.

A PFEIFFER SEGMENTED BALL VALVE AS SUPPLEMENT

In addition to the Type 14p - PSA Valve, PFEIFFER developed a further butterfly valve for PSA applications based on the design of a segmented ball valve.

Similar to Type 14p, the Type 16p - PSA Control and Shut-off Butterfly valve (Fig. 4) has a rugged valve body and a butterfly disk specially developed for PSA applications.

The divided shaft and increased eccentricity create a comparatively larger cross-section of flow, which results in an improved flow of gas through the PSA plant.

The Type 16p - PSA will be available in 2017.

CONCLUSION

This article has shown that the described PFEIFFER butterfly valve with instrumentation reliably meets the high demands placed on valves used in PSA plants.

The operational reliability of up to one million switching cycles is guaranteed and the requirements for seat leakage and fugitive emissions are fulfilled as well.

AUTHORS



Amjed Slim, B.Sc. Wirt.-Ing.

Head of Product Management for Butterfly valves, PFEIFFER Chemie-Armaturenbau GmbH, Kempen, Germany

Phone: +49 2152 2005-481

amjed.slim@pfeiffer-armaturen.com



Nadine Wetzstein, M.Sc.

Head of Flow Lab at the Global Innovation Center, SAMSON AG, Frankfurt/Main, Germany

Phone: +49 69 4009-2269

nwetzstein@samson.de



Dipl.-Ing. Marcus Miertz

Managing director of PFEIFFER Chemie-Armaturenbau GmbH, Kempen, Germany

Phone: +49 2152 2005-607

marcus.miertz@pfeiffer-armaturen.com



Dr. Jörg Kiesbauer

Member of executive board for R&D at SAMSON AG, Frankfurt/Main, Germany

Phone: +49 69 4009-1300

drjkiesbauer@samson-ag.com