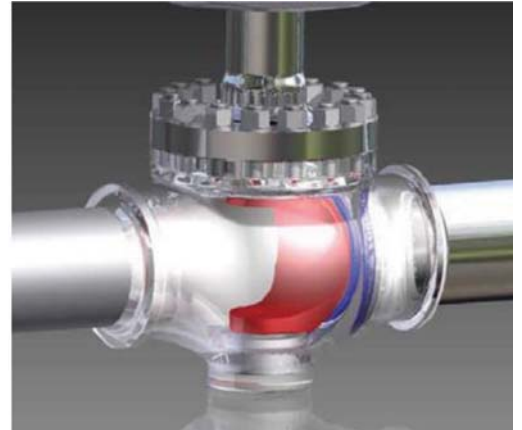


# “Eccentricity” can enhance valve performance

This article describes the major historical design improvements that have been implemented on ball and butterfly valves and the impact that these modifications have on valve performance. This document further explains the technical revolutions in valve design that have led to valves with extraordinary performance, such as the evolution to quadruple (4th) offset butterfly valves and double (2nd) offset ball valves.



The QUADAX quadruple offset butterfly valve and the A.E.V double offset C-ball valve

**B**all-and butterfly valves are commonly used in the industry as isolation or on/off valves, thus perfectly blocking the media (fluid or gas) in a pipeline when they are in the closed position.

By perfectly blocking, it is understood that the valve will maintain the pressure in the upstream and that the valve will have no leakage, regardless of the process conditions (pressure, temperature...).

The easiest way to achieve perfect tightness is to use a soft material (seats) that will be elastically deformed by the obturator (disc or ball) when the valve is closed (see Figure 1). When the valve is opened the seat will regain its original shape. This design is commonly named soft seated valves. Although this is a very efficient design to achieve perfect tightness, this design is limited by the mechanical properties of the soft seat itself. The use of soft seats inherently limits the minimum and maximum temperature of the valve. The limits are approximately  $-10^{\circ}\text{C}$  up to  $+140/200^{\circ}\text{C}$ . If the valve is used on applications where the temperature is below or above the temperature limits of the seat, the seat will lose its resiliency (elasticity) and the valve will leak.

Besides the temperature limitation, the use of soft seats also limits the maximum allowable working pressure. It is obvious that for too high pressures (or vacuum), the seat could be

deformed or even displaced (blown out), causing the valve to leak.

In addition to the temperature and pressure limitations, the use of soft seats makes the valves vulnerable to the effect of wear. The deterioration of the soft seat and consequently the lifetime of the valve strongly depend on the process fluid (which may be abrasive or erosive) and also the operating conditions (such as high cycling or quick acting). Because the wear of the soft seat will eventually cause the valve to leak, the use of soft seats is inappropriate for these kinds of applications.

## Eccentric principles

The solution to guarantee perfect tightness at a wider temperature and pressure range and to eliminate the effect of wear is to use an eccentric design. The basic principle of an eccentric design is to not align the axis of rotation of the obturator with the centerline of the seat area.

This design is similar with the design of a door, where the hinge is not aligned with the wall, nor is the hinge mounted in the center of the door. In valve terminology this is called a double eccentric design (see Figure 2).

Double eccentric designs are commonly used for butterfly valves, also called High Performance butterfly valves. The first and most obvious benefit of this design is the reduction of wear. Comparable with the friction of a door, the disc is only in

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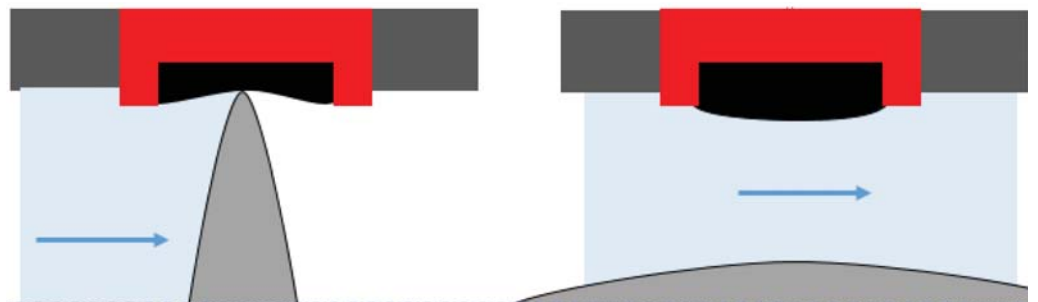


Fig. 1: Cross-section of a butterfly valve with the disc in the closed and open positions. Note the seat deformation when closed. ►

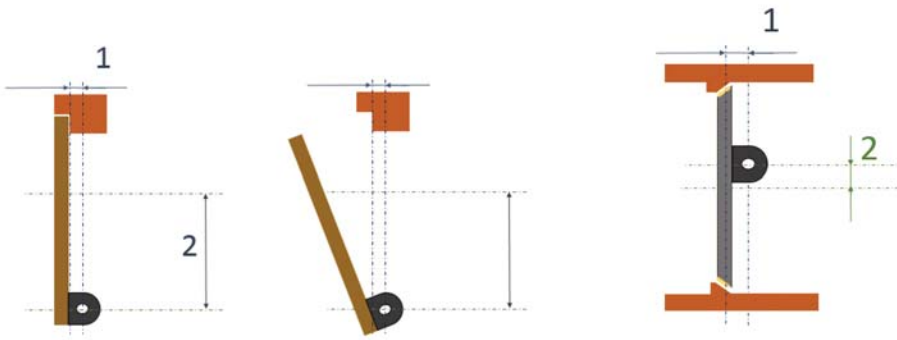


Fig. 2: Showing the resemblance between a door (shown here in the closed and open positions) to a double eccentric butterfly valve

contact during the first degrees of movement in the opening stage. After the initial opening there is no contact and thus no friction between the seat and the disc. This characteristic of the double eccentric design makes the High Performance butterfly valve more suitable for high cycling or quick acting (e.g. in Emergency Shut Down or ESD) valves than a conventional, centric butterfly valve. In order to achieve perfect tightness, the double eccentric design can be combined with the use of soft seals, usually RPTFE. By using this soft seat, the high performance butterfly valves are perfectly tight, but are limited in terms of the pressure and temperature range.

**Perfect tightness**

A logical evolution in the design of butterfly valves was to develop a design that would have a perfect tightness for a wider temperature and pressure range. This has been achieved by adding a third eccentricity to the design, called triple eccentric or triple offset valves. As the goal was to develop a design that could withstand very low and very high temperatures, the soft seat which was used to achieve tightness had to be substituted. The use of a metal seal had to be considered. In order to have some elasticity, to achieve the required tightness, it was realized that a lamella seat was the most appropriate solution. The lamella seat consists of several stainless steel rings with graphite in between (see Figure 3). As the aim was to have a perfect tightness



Fig. 3: Stainless steel- graphite Lamella seat

whilst using a metal lamella seat, the third eccentricity was introduced. The third eccentricity is basically the machining of the seat area in the body to a special shape (see figure 4). This specific shape of the body seat area will allow the metal lamella seal to expand due to the radial forces that would be created when a torque is applied. In order to achieve perfect tightness, the seat area in the body is usually covered with a Stellite overlay. Compared with the double eccentric or high performance butterfly valve, the third eccentricity offers additional benefits alongside the 'low wear' advantage of the first two eccentricities. Due to its design, only metal parts are involved (no soft seats/seals), the temperature range is expanded from -270°C up to +800°C, the design is inherently fire-safe and the pressure rating increases up to 200bar. This design can be used for wide

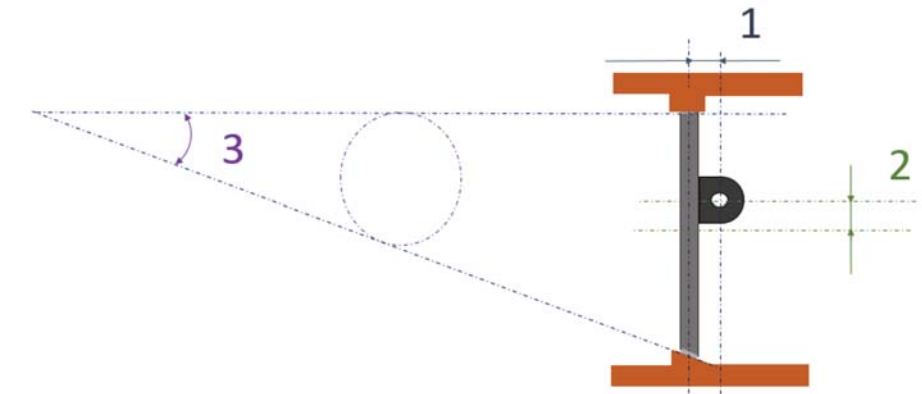


Fig. 4: The triple eccentric- triple offset design

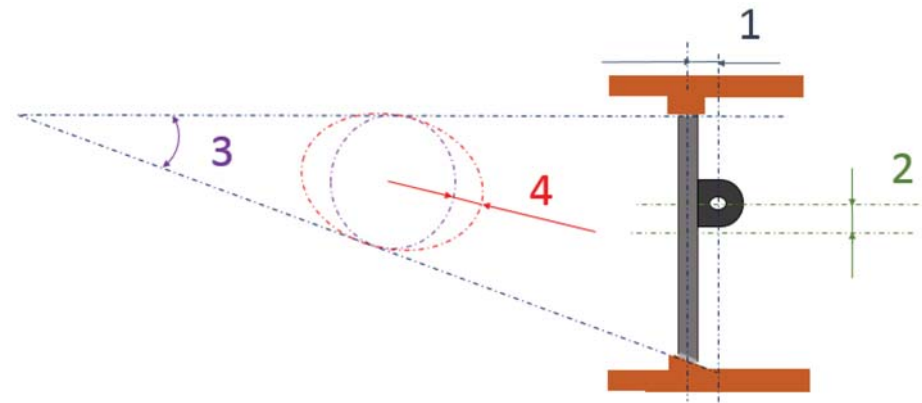


Fig. 5: The quadruple eccentric - fourth offset design

variety of applications from cryogenic to very high temperature.

Today, a four offset butterfly valve, designed and manufactured by Quadax, has proven that the performance can be improved further still. The fourth eccentricity is basically an adjustment of the third eccentricity and works by creating a different shape for the body seat area. Whilst the seat in a triple eccentric design is not perfectly round, the result of the fourth eccentricity is a perfectly round seat (see Figure 5).

This change results in a significant improvement of the flow coefficient (CV) of the valve, which means that the pressure drop created by the valve, for a given flow, will be lower for a quadruple offset valve than for a triple offset valve. We can state that the design of a four offset valve is more efficient than a triple offset valve.

Besides that, and because the seat area has a perfectly round shape, the four offset design allow the use of a floating disc. In most triple offset valves, the disc is fixed to the shaft. The floating disc design, together with the round sealing support of the QUADAX quadruple offset valve, results in a better tightness even in high temperature applications. A variation in temperature will cause the valve body, the shaft and the disc to dilate, unfortunately not equally because of the differences in shape and mass. With the floating disc design, the disc can move freely and

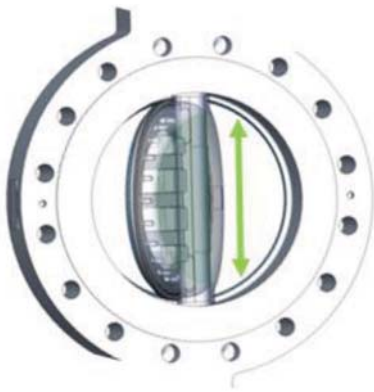


Fig. 6: The four offset design enables the disc to move freely which results in a better tightness

will center itself in the seat area, which results in a better tightness (see Figure 6). The four offset is the latest butterfly design and offers a lot of benefits compared with the previous butterfly valve designs. The design will most certainly evolve, with the focus to reduce the torque requirements whilst maintaining the tightness performances.

**Double offset ball valve**

However, there are a few applications for which the Quadax quadruple offset is not suitable. For example, when the application requires a full bore (design without a disc) or the service includes abrasive and erosive fluids or gases. For these specific and difficult applications, another revolutionary design has brought a technical solution, meeting the highest

Table 1: A comparison of valve performance versus design

	Butterfly valve				Ball valve	
	Centric	2 offset	3rd offset	Quadax 4 offset	Conventional	A.E.V double offset
Wear/friction	Red	Grey	Dark Blue	Dark Blue	Red	Dark Blue
Temp/pressure range	Red	Dark Blue	Dark Blue	Dark Blue	Red	Dark Blue
Flow coefficient	Red	Dark Blue	Dark Blue	Dark Blue	Red	Dark Blue
Tightness at high ΔT	Red	Dark Blue	Dark Blue	Dark Blue	Red	Dark Blue
Abbrasive/erosive service	Red	Dark Blue	Dark Blue	Dark Blue	Red	Dark Blue
Fire safe	Red	Dark Blue	Dark Blue	Dark Blue	Red	Dark Blue
Full Bore	Red	Dark Blue	Dark Blue	Dark Blue	Red	Dark Blue

standard for every valve characteristics, the double offset ball valve.

The properties and limitations of a soft seated, trunnion mounted ball valves are similar to the limitations and constrains of a centric, soft seated butterfly valve. Instead of a disc, a ball is used as the obturator. The obvious advantage of a ball valves compared to a butterfly valve is the full bore and the pressure rating that is higher than for soft seated butterfly valve (see Figure 7).

The ball and the seat in a conventional trunnion mounted ball valve are continuously in contact, thus vulnerable to dust and particles, which could damage the seat and cause the valve to leak. The tightness is achieving by the pressure from the upstream fluid, which pushes the seat against the ball.



Fig. 9: The ball and stem – coated for abrasive services – on a double offset ball design

A.E.V has designed a double offset ball valve using a C-ball as obturator, which resulted in more benefits and improved performance. As the rotation axis is eccentric, there is no friction between ball and body during the operation which extends the lifetime of the valve (see Figures 8 and 9).

This unique and revolutionary design combines the benefits of a quadruple offset butterfly valves with the benefits of a ball valve. Advantages include: full bore (excellent flow coefficient); friction free (so no wear due to the eccentric design); tightness at very low and very high temperatures, torque seated valve; less weight than a conventional ball valve (C-ball); bi-directional service; no cavity; excellent performance on abrasive or erosive service; top entry design (maintenance can be performed in line).

**Field experiences**

Our experiences with both the Quadax triple offset valves and the A.E.V double offset ball valves are excellent. We have supplied manual or automated models to a variety of customers and for various applications. Due to their unique design and properties these valves are suitable for every application, including steam, cryogenic, high pressure gas, oxygen, oven gas, molten salt, reactor valves, etc. Table 1 compares these designs to the standard ball and butterfly valves.

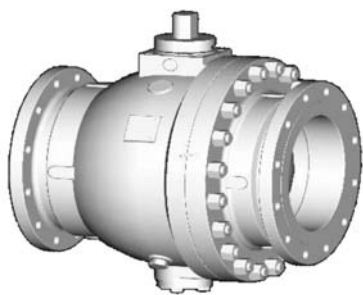


Fig. 7: The trunnion-mounted ball valve in the closed and open positions

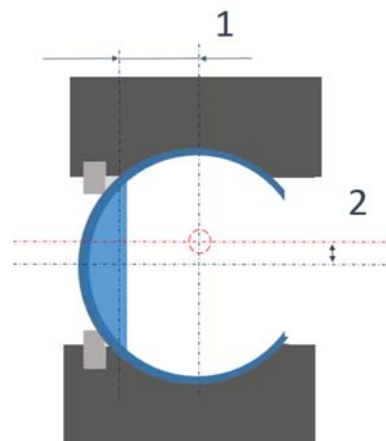
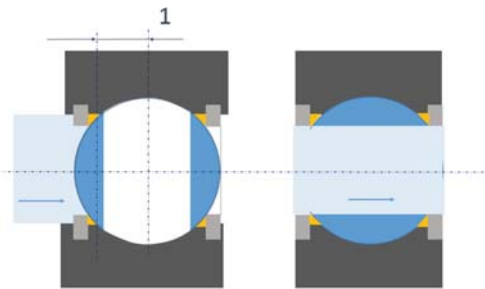


Fig. 8: The double offset design from A.E.V.

