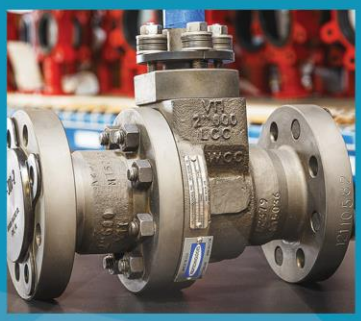
Is a Butterfly Valve just a Butterfly Valve?









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Is a Butterfly Valve Just a Butterfly Valve?

In the world of valves it is very common for many to categorize valves and have the perception they are all created equal and/or share the same performance characteristics. The category of butterfly valves is a good example of this belief. The term butterfly valve has been applied to this design due to the similarity of the internal modifier, the disc, and the shaft which closely mirror a butterfly's wings and body.

The general category of butterfly valves typically applies these designs:

- Damper
- Resilient Seat Butterfly Valves (RSBFV)
- High Performance Butterfly Valves (HPBFV) or more accurately Double Offset Butterfly Valves also known by some as Eccentric Butterfly Valves
- Single Offset Butterfly Valves
- Triple Offset Butterfly Valves

Is one butterfly valve equal to another butterfly valve? The answer is not a simple one as there are a great number of different designs in the category. The best way to categorize butterfly valve designs is in the way they provide isolation performance or create interference with the sealing components; in order to maintain some level of categorization, we can define butterfly valves by either being Position Seated or Torque Seated.

The torque seated butterfly valve was developed in the mid 1950's with the first Triple Offset Rotary Tight Shutoff Valve that was patented by Karl Adams in 1960. This metal seated valve was designed to replace leaking wedge gate valves in district heating systems in Europe; the three design premises were zero leakage, zero friction and zero maintenance.

The Triple Offset Rotary Tight Shutoff Valve has become a mainstay in handling Liquid Natural Gas, Liquid Nitrogen and other gas liquid applications around the world. This will be the focus of the article to identify the differences between butterfly valve designs.

The ADAMS Rotary Disc Shut-off Valve's long service life and tight shut-off performance are a result of a unique triple offset design, elliptically machined disc and a body mounted laminated stainless steel/graphite seat ring. These standard features combine to provide the solid solution to the significant problems inherent to conventional butterfly valves, whether concentric, single offset or double offset (aka High Performance Butterfly). We offer a summary of these standard features as follows:

Triple Offset Design

The unique triple offset of the valve means the seating is effected with almost zero friction. The disc lifts off the seat without dragging across the surface. Because of this feature, these valves could be placed through 500,000 cycles of operation without any degradation in seating performance.

Figure 1 illustrates the inclined conical sealing principle utilized by the triple offset design. The diagram below illustrates the principles of the triple offset design:

- Offset 1 - The inclined angle on the conical disc allows simultaneous engagement of the disc to the seat ring without friction.
- Offset 2 - Shaft centerline is offset from the pipe/valve centerline to provide the camming action.
- Offset 3 - Shaft centerline is offset away from the centerline of the disc and sealing surface, thus allowing uninterrupted metal to metal contact between the disc and seat ring.

The combination of these three offsets provides a disc lifting action, which ensures a frictionless (almost zero) repeatable seating. This triple offset camming action provides the wiping mechanism necessary for systems that are subject to media with abrasive, silting, scaling or biological growths. These growths or particles are swept away from the seating surfaces prior to disc and seat engagement, maintaining the leak tight integrity required in isolation/control applications.

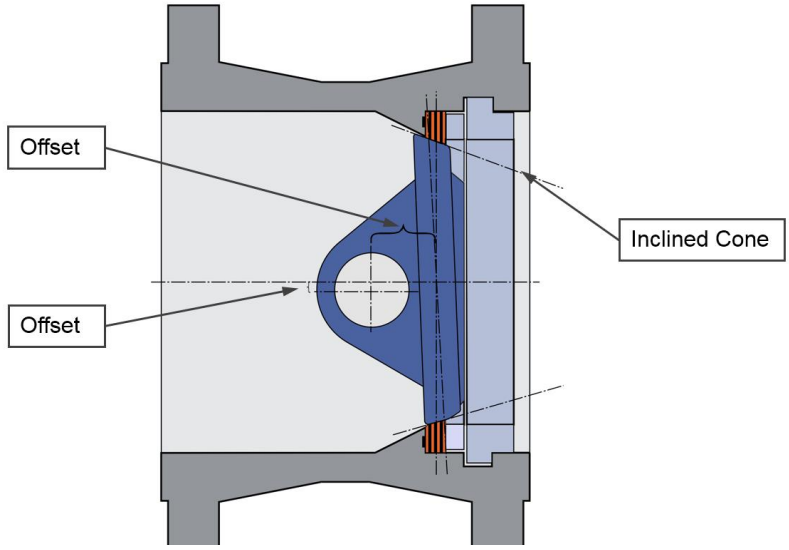

Figure 1: What is this?.

Torque Seating

The key design feature in the triple offset design, torque seating combined with a body mounted metal-to-metal seat, allows the disc to routinely return to the proper closed position without using mechanical stops. It seats repeatedly with virtually no friction due to the triple offset design enhanced by the massive shaft (double flanged or ASME B16.10 end to end dimensions), disc and valve actuator interface. This feature, combined with margins on dynamic and static torques, leads to very consistent stroke times and 89-10 results. In tight shut-off applications, it is critical to return the disc to its proper seating position during each cycle of operation.

The torque-seating feature of the triple offset valve means that you do not have to rely on actuator limit stops to determine the shut-off position of the disc. In the ADAMS valve design the actuator torques the disc into the seat in every cycle of operation. The actuator stops are only used to prevent over travel. This eliminates the major cause of leakage and failure in standard "position seating" butterfly valves.

Internal Design

The triple offset metal seated valve design is the optimum choice for cryogenic and gas liquids handling as there is no internal trapped cavity area for liquids to collect. In the event of liquids expansion, the pressure would simply move upstream or downstream within the piping system, thus causing no valve damage that can occur in wedge gate, plug or ball valve type products. The metal seated system of the triple offset valve will

provide repeatable tight shutoff exceeding the criteria of ASME B16.104 Class VI, whereas metal seated designs of double offset valves are typically Class IV or V shutoff; soft seated versions are not capable of the low temperatures that can be seen in cryogenic applications. See below comparison between, where triple offset valves are tested according to API 598 Resilient Seat category.

Leak Rate Comparison										
ND		ANSI/FCI 70-2 Cl. VI	API 598				API 6D		ND	
			Metal Seated		Resilient Seated					
		Air	Air	Liquid	Air	Liquid	Air	Liquid		
		Bbl/Min	Bbl/Min	Drop/Min	Bbl/Min	Drop/Min	Bbl/Min	Drop/Min		
3"	75mm	6	24	12	0	0	0	0	75mm	3"
4"	100mm	11	24	12	0	0	0	0	100mm	4"
6"	150mm	27	24	12	0	0	0	0	150mm	6"
8"	200mm	45	40	20	0	0	0	0	200mm	8"
10"	250mm	70*	40	20	0	0	0	0	250mm	10"
12"	300mm	100*	40	20	0	0	0	0	300mm	12"
14"	350mm	136*	56	28	0	0	0	0	350mm	14"
16"	400mm	176*	56	28	0	0	0	0	400mm	16"
18"	450mm	225*	56	28	0	0	0	0	450mm	18"
20"	500mm	278*	56	28	0	0	0	0	500mm	20"
24"	600mm	400*	56	28	0	0	0	0	600mm	24"
30"	750mm	620*	56	28	0	0	0	0	750mm	30"
36"	900mm	900*	56	28	0	0	0	0	900mm	36"

1 Drop = 0.0625cm^3 (16 Drops = 1 cm^3) 1 Bubble = 0.15cm^3 *Extrapolated Values Not Included in Test Standard

Laminated Stainless Steel and Graphite Seat Ring

The seat has operated in harsh environments such as saturated steam, abrasive media, and with silt and rust particles in the flow stream, while providing long-term maintenance-free shut-off. Graphite enhances the rotary disc's zero-leakage capability. It adds lubricity and fills voids during the "squeeze" taking place when the disc is rotated into the seating surface. The stainless steel rings develop a flexible sealing system highly tolerant to deleterious effects of poor media conditions. Conventional butterfly valves with soft seats, such as PTFE Teflon, ultra-high molecular weight polyethylene (UHMWPE) or elastomers, may be tolerant to the effects of radiation aging but will still require maintenance attention during outages. Closing or opening of the valve can position a disc in such a manner as to tear the soft seat during the action of repositioning the disc to seat after inspection for erosion or biological attachments.

Sear Retained in Body

Removal of the seat, if required, is a process employing the removal of standard set screws from a retaining ring. The valve will not require complete valve removal should damage occur to the seat ring, as long as access to the seat ring is provided by a spool piece or access panel in the valve body. The simple field replacement of the seat ring does not require any special positioning, keeping down-time to a minimum.

Metal-to-Metal Seating

The standard metal-to-metal seating allows placing it into a broad range of services. Conventional soft-seated butterfly valves are placed into services where low and/or high temperature fluctuations and severe service conditions require special modifications which may not last. See Table 1, which provides a comparison for review of the ADAMS valve to conventional soft-seated butterfly valves. The ADAMS valve requires no modification in the same application.

Better than ASME Class VI Leak Integrity

Shut-off in the normal flow direction and up to 60% of rated pressure in the reverse direction is in excess of ASME Class VI, it is absolutely zero leakage, and can be tested with Helium. Flow in the reverse direction above 60% of rated pressure is equal to Class VI. This is achieved by the sealing system: triple offset, laminated stainless steel/graphite seat ring, and seat in body. This design means that for most services, the original triple offset valve will provide zero leakage isolation bi-directionally!

One Piece Shaft

The self-lubricated, corrosion-resistant shaft bearings are designed to eliminate body galling. The lower thrust bearing is a blowout-proof design. These features, combined with the single piece forged disc, provide trouble-free service, eliminating disc jamming or separation problems.

Oversized Drive Components

Another important feature for your application is the oversize drive components of the double flanged or ASME B16.10 dimension valves. By using a large disc and shaft combined with precision fit keys, hysteresis and dead band are eliminated. In continuous throttling service the disc and actuator drive system must act as an integrated unit to provide proper control. In addition, the slightest looseness will lead to vibration, oscillations and rapid failure of internal valve components. This can be a serious concern in high performance butterfly valves which use wedge or taper pins in their drive systems.

Comparison of ADAMS Valve to other Butterfly Valves

Comparisons of the ADAMS valve to other rotary disc valves is shown on Table 1. Designs with the seat mounted in the disc require higher shaft offsets, subjecting the valve components to more deflection, and hysteresis. A simple comparison of the thickness of the ADAMS valve disc to the thickness of a disc-mounted seat illustrates the weakness of the design. A disc mounted seat will deflect significantly while the ADAMS valve disc is virtually unaffected by the system pressure. The deflection of the disc mounted seat design will lead to uncontrolled friction when pressure pushes the seat into the body and severe leakage when the pressure is reversed.

Protection of the seat ring is another major deficiency of the seat located in disc valve design. It exposes the seat to the system flow and the resulting effect is seat erosion.

With the seat located precisely in the flow stream, fluid borne media will impinge on the laminated seat and erode it. The ADAMS valve body mounted seat is protected from the fluid media and has not shown problems with erosion even in abrasive services.

The ADAMS valve seating system utilizes a body mounted seat ring which provides for easy field replacement should the seat ring become damaged. The seat mounted in the disc valve design must utilize a special seating surface integral to the body. Should this integral seating surface become worn due to wire drawing or damaged during normal maintenance it must be removed from the system and returned to the factory. This is a very serious maintenance problem.

TABLE 1: Comparison of ADAMS Valve to Conventional Butterfly Valves

Features	ADAMS	Butterfly Valves
Shaft Diameter	Large and robust	Slender
Shaft to Disc Connection	Two precision keys to eliminate backlash and hysteresis	Wedge of taper pins
Shaft to Mounting Hardware	Two precision keys	One slotted key
Mounting Hardware to Operator Connection	Precision register diameter provides precise alignment to prevent side loading on shaft/bearings	Slotted shaft with mounting bolts
Packing and Land Bolting	Four bolts	Two bolts
Seat Location/Retention	Seat located in valve body out of direct impingement of flowstream. Seat is held in place by retaining ring with set screw hardware shielded from flowstream.	Seat located in valve disc which is subjected to direct impingement of flowstream. Seat is held in place by retaining ring with set screws, also subject to direct impingement of flowstream.
Seat Replacement	Field repairable. Requires no special seat alignment. Retaining ring screws out of the flow path.	Field repairable. Position seating required; seat must be floated into place and checked for positive isolation. Several iterations may be required to accurately locate seat to ensure isolation and prevent permanent damage. Should integral body seat become damaged, it must be returned to the factory.

Table 2: Comparison of Adams Valve to Conventional Rubber Seated Butterfly Valves

Features	ADAMS	Butterfly Valves
Shaft Diameter	Large and robust. Rated to full ASME B16.34 differential shutoff.	Slender. Usually rated to a lower pressure
Shaft to Disc Connection	Two precision keys to eliminate backlash and hysteresis	Taper pins that can easily shear under excess load.
Shaft to Actuator Mounting Hardware	Two precision keys, reduces hysteresis due to backlash	One slotted key, can cause excessive hysteresis
Mounting Hardware to Operator Connection	Precision register diameter provides precise alignment to take torsional loads and prevent side loading on shaft/bearings	Slotted shaft with mounting bolts can cause excessive stem deflection, resulting in packing leaks
Packing and gland Bolting	Four bolts; even packing pressure prevents packing leaks	Two bolts; may result in pre-mature packing leaks
Seat Configuration	Stainless Steel Graphite; Wide band contact surfaces resists damage from raw service water debris	E.P.T. material; Not tolerant to raw service water debris – easily damaged
Seat Location/Retention	Seat is located in valve body out of direct impingement of flowstream. Seat is held in place by retaining ring with setscrews and shielded from flowstream. Seat does not require to be indexed, prior to replacement.	Seat located in valve body is subjected to direct impingement of flowstream. Seat is forced fit into the valve body.
Seat Replacement	Field repairable. Requires no special seat alignment or tools.	Not Field repairable. Must be sent to the factory for new seat to be installed. Position seated disc several iterations to accurately locate seat to ensure isolation and prevent permanent seat damage.

CGIS understands and realizes that we should and can expect more from industrial valves today, which is achieved by knowing the application and purpose of the valve. In addition, we also encourage valve users to have valve categories that are less general in nature in order to have the specific valve technology available to find the right valve. In doing so we believe, valve choices and selection will lead to enhance reliability and performance while reducing cost of ownership surrounding manual and control valves.

The butterfly valve category is one where in lies a wide range of valve products that may suit one, but not necessarily another application. In addition, it can lead to poor valve choices of users that are not aware of the many differences between various butterfly valve designs. In fine tuning and creating specific butterfly valve design categories, more effective and suitable valve decisions can be made.