Why A Butterfly Valve

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I. Introduction

The basic concept of the butterfly valve can perhaps be best illustrated by comparison with a damper in a flue pipe: a round disc, of essentially the same diameter as the pipe, rotating on an axis at a right angle to the pipe centerline. When closed, the disc is positioned at a right angle to the fluid flow; when open, the disc is parallel to the fluid flow. The butterfly valve is thus a rotary, quarter-turn valve. The name "butterfly" derives perhaps from the appearance of the stem-disc assembly, which bears some resemblance to the body and outstretched wings of a butterfly.

II. Development History

Butterfly valves, in the form of dampers, have been used as flow control devices for centuries. In these early devices, the disc had no seating surface as such. The edge of the disc merely swept the inner diameter of the pipe to alter flow without ever achieving tight shutoff. The devices were very inexpensive to manufacture since the only parts nedded were a stem and disc, using the pipe itself as the valve body.

With the advent of rubber liners, which closed the gap between the disc edge and the pipe or valve body, the damper became a tightsealing valve. While natural rubber liners were not successful in this application, the development of synthetic rubbers in the 1950's offered the non-sticking, non-swelling characteristics required for acceptable long-term sealing.

Soft rubber liners seal by allowing the edge of the disc to compress the rubber, producing a local contact pressure higher than the line pressure. Typically, tight shut-off with soft rubber liners is limited to pressure differentials on the order of 150 to 250 psi.

To seal against higher pressures, the edge of the disc would have to severly compress the rubber liner, resulting in high operating torque and destructive wear on the liner.

Left in the closed position for an extended period of time under higher pressures, the rubber tends to deform permanently, bulging out on both sides of the disc edge and making it difficult or impossible to open the valve.

The rubber liner is also limited to temperatures below about 300°F and to fluids that will not have an adverse chemical reaction on the rubber.

The development of tetrafluoroethylene (TFE) offered a material that has many desirable properties for valve seals and seats. Since TFE is not nearly as resilient as rubber, it could not be directly substituted for rubber in order to upgrade the performance of rubber-lined valves. In fact, much development work had to occur before seats were designed that could exploit the capabilities of TFE and similar plastics in the areas of pressure, temperature, chemical inertness and low operational torque.

The result of these develpments transformed the butterfly valve into today's high-performance butterfly valves for pressure up to 1480 psi and beyond.

III. Economic Factors

The single most important reason for selecting a butterfly valve is its low cost compared to other types of valves on the market today. A related advantage is the compact size and light weight of a butterfly valve, which results from its smaller end-to-end dimensions.

Installation costs, like initial costs, are equally attractive. A small maintenance crew, for example, can easily intall or replace a 1 6-inch butterfly valve without using mechanical lifting equipment. Economies are also possible with pipe hanger supports and other installation and preparation expenses.

Seat replacement, particularly in high-performance butterfly valves is relatively simple. Stem packing can be replaced without disassembling stem and disc and, in many installations, without even removing the valve actuator.

Butterfly valves are often specified for throttling and flow regulating service because of the inherent approximately "equal percentage" flow characteristics, as differentiated from the linear or quick-opening flow characteristics of some other valve type.

IV. Types and Codes

While there is a great diversity of butterfly valves on the market today, there are three primary groups, each of which is defined by applicable industry codes and standards.

Industrial Rubber-Lined Butterfly Valves

Applicable Standards: MSS-SP67, API 609 (October, 1983 Edition)

This type makes up the largest segment of the total butterfly valve market and is generally offered at the lowest price. While limited in its applications, as noted below, current models of this type of butterfly valve are much improved over earlier models. In those models, the stem on which the disc was mounted passed through the centerline of the valve body - and through the top and bottom of the rubber liner. The two points where the stem passed through the liner were difficult to seal and through leakage at these points was a common problem.

In the early 1960's, the problem was corrected by off-setting the stem from the valve centerline so that it did not pass through the sealing area of the rubber liner. The liner thus provided a continuous, uninterrupted seal area through a full 360°.

Despite improved sealing, however, the use of a rubber liner generally limits maximum differential pressure to around 285 psi, the maximum rating of ANSI 150. Resistance of the rubber liner to various fluid media and higher temperatures imposes further limits on applications.

Water Works (AWWA) Butterfly Valves

Applicable Standards:	Rubber lined - ANSI/AWWA C504
	Metal seated - AWWA C505

Though usually limited to water and sewage, these valves are occasionally specified for other services. They are supplid in smaller sizes as rubber-lined valves with extra heavy stems and in large sizes - up to 72 inces - with adjustable seats. The rubber-seated valves are generally limited to 150 psi differential pressure. So-called metalseated valves of this type (which have no seat except for the close proximity of the disc to the wall of the flow passage) are generally limited to 200 psi pressure differential.

The American Waterworks Association (AWWA) specifies end-to-end dimensions, body materials, minimum shaft diameters and stem materials as well as several other design parameters.

High-Performance Butterfly Valves

Applicable Standards:	API 609 (October, 1983 Edition) and MSS-SPXX (in development - number not yet assigned)

As mentioned earlier, this is the latest type of butterfly valve on the market today. It was not until October of 1983, in fact, theat an industry standard was produced indicating its acceptance in the valve market. Other industry standards are expected to follow shortly.

High-Performance butterfly valves (HPBV's) are rather sophisticated valves designed for tight shut-off at relatively high tempertures and pressure (as compared to other types of butterfly valves.) They have dynamic (pressure assisted) TFE sealing and have full ANSI pressure ratings in classes 150, 300 and 600 (1480 psi) or higher at ambient temperatures.

Temperature capability ranges up to 450°-500°F, although pressure ratings are significantly reduced at the higher temperatures.

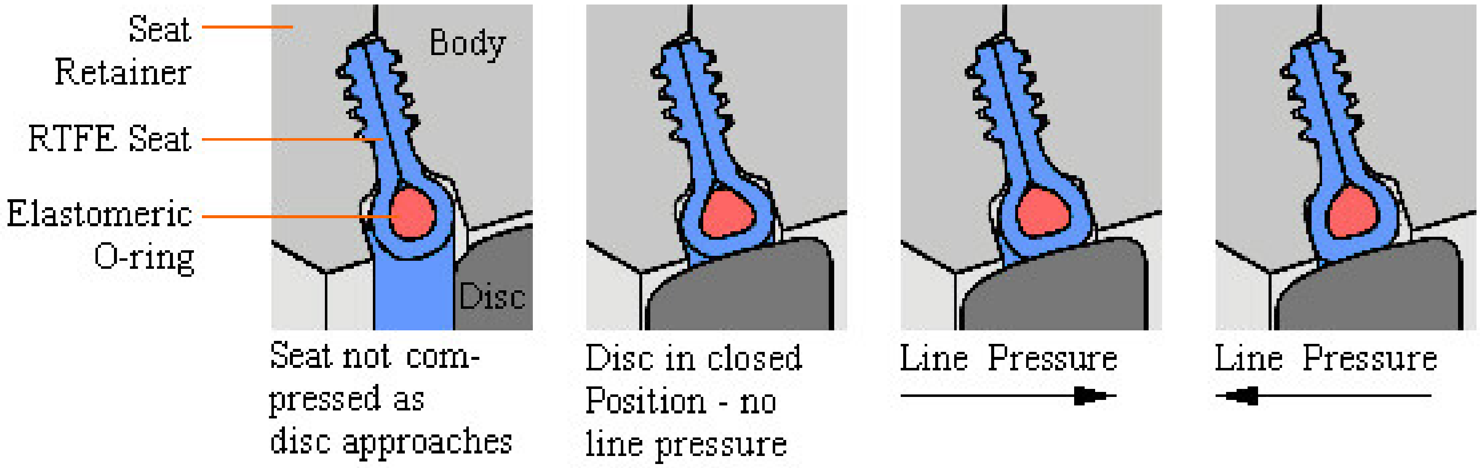
The inherent cost advantages of a flangeless or wafer-type butterfly valve (designed to be bolted between pipe flanges,) when combined with higher pressure/temperature capability, has created an enourmous market for HPBV's where gate and glove valves were previously used. Further developments with the HPBV have resulted in versions which are fire-tested for flammable liquid service, versions for cryogenic services at -320°F and, most recently, versions with metal seats which push teh capability of the valves into applications which had been exclusively held by gate, globe and plug valves.

V. HPBV Design

The performance of a HPBV is dependent on the seat design, along with several other design considerations. All HPBV's presently on the market are designed with an offset seat, the seat is set off to one side of the stem to provide an uninterrupted circular seal ring against which the disc seats when closed. The TFE seats can be designed so that fluid line pressure acts upon the seat to increase the contact pressure between seat and disc very similar to an O-ring sealing concept. This results in a leak tight valve at all rated pressures.

A properly designed seat should provide bi-directional, tight shutoff, sealing drop-tight at high as well as low pressure differentials. It should also produce a low operating torque, should be self-cleaning (not become packed with suspended solids in the fluid media,) and should perform all of its required functions within the normal pressure/temperature ratings of the valve.

All these requirements for good seat design can be achieved only with an extremely flexible and resilient seat. The Bray/McCannalok Series 40 HPBV seat meets these design requirements as illustrated below.



Most high-performance butterfly valves on the market today employ a second, almost imperceptible offset of the disc. These valves are sometimes referred to as "double offset" high-performance butterfly valves.

When the stem of such a valve is rotated (see illustration below,) the second offset provides a camming action whech, in the fully open position, completely removes the disc from any any contact with the seat. Without this offset, the disc would stay in constant compressive contact with the seat in the two areas where the plane of the disc intersects the plane of the seat. In this situation, after the valve has remained open for a long time - and especially after a few temperature cycles - the compressive contact of the disc with the TFE seat should result in a permanent indentation of the seat in these two areas. When the valve is then closed, these two indentations in the TFE seat would not resume their former shape and leakage would eventually be experienced in the two areas. The "double-offset" design eliminates this problem.

Recent improvements in HPBV's have also been made in bearings and stem seals - all of which have made it possible to achieve reliable valve operation through 100,000 or more valve cycles. And the use of exotic body and trim materials - such as Stainless Steel 316, 17-4PH, Alloy 20, Monel and aluminum bronze - have extended use of these valves into a great many corrosive applications.

VI. Conclusion

All butterfly valves in today's market are not alike. There are several distinct types, each having its own performance characteristics and preferred applications. It is anticipated that continuing advances in technology will further enhance butterfly valve performance and broaden applications. Even so, no single type can fully satisfy every application. There will always be need for all types of butterfly valves mentioned in this article.

As industries strive to reduce construction and operating costs, however, butterfly valves seem certain to appear more frequently in the notebooks of applications engineers. And continuing favorable user experience will no doubt open many new applicatoins for high performance butterfly valves.
