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New Developments in Butterfly Valves

THE AUTHORS

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ABSTRACT

Butterfly valves are made with distinct features and end-to-end dimensions, meeting several industry standards. They can be broadly classified as: rubber-seated and high-performance (HPBV) butterfly valves. The rubber-seated valves are well suited for on/off applications at lower operating pressures and are very economical, however the HPBVs offer chemical inertness and superior performance at higher pressures and temperatures. Like other types of valves, butterfly valves have certain drawbacks, and not all of them are properly designed. However, in many applications in the fleet, which have required traditional gate, globe and rubber-seated butterfly valves in the past, HPBVs offer improved performance and substantial economies when a well-designed HPBV with the desired features is selected and installed with due considerations.

INTRODUCTION

"I am fed up with butterfly valves. They are worthless. I wish I could replace them with the time-proven gate valves." This remark was made by a maintenance superintendent at a recent hull, mechanical, and electrical (HM&E) conference. If you also have had problems with butterfly valves, then you may have plenty of company!

It seems that more complaints are being heard about butterfly valves, but why is this so? One reason is that their use is on the rise substantially. Engineers are specifying them rightly or wrongly for just about any application — using them in place of many of the traditional valves such as globe, gate, plug or even ball valves. Some of the more difficult applications which needed speciality valves in the past, such as cryogenic services, high temperature, high pressure, vacuum, slurry, and even fire-prone applications, have recently seen the use of butterfly valves.

Why have butterfly valves become so popular? One reason is their initial cost, which can be substantially lower than other types of valves available in the market. Another reason is the development of the high performance butterfly valve (HPBV) which, according to its manufacturers, has extended the capabilities of butterfly valves into performing many of the tasks reserved for traditional and more expensive gate and globe valves. If all of this is true, then why is there so much dissatisfaction among users? Often, when losses due to maintenance and equipment shutdown are encountered, many of these butterfly valves may not be the bargain they had seemed.

The truth is that if a carefully designed and manufactured butterfly valve is selected for the right application and is installed with proper considerations, it may outlast all other types of valves at a fraction of the overall cost. However, it should be noted that no one single type of valve is the right valve for *all* applications, and every type of valve has its inherent advantages and disadvantages.

TYPES OF BUTTERFLY VALVES

Since there are a variety of butterfly valves on the market, made to various industrial and military specifications, with different end-to-end dimensions (see Table 1), it may be appropriate to acquaint ourselves with the types of valves available. There are basically two major categories of butterfly valves: rubber-seated (also

- The omnidirectional wheel significantly outperforms a worn nonpneumatic tire in driving traction on a smooth ice surface.
- On hard-packed and fresh snow, a conventional all-season radial tire provides notably better driving traction than the omnidirectional wheel. The omnidirectional wheel also does not perform as well as a bias-ply highway tread tire (used on MD-3) on fresh snow.
- The omnidirectional wheel shows a broad peak traction region on a drawbar-pull vs. slip curve with a desirable slow tapering off of force after the peak value is reached. This characteristic makes the omnidirectional wheel "user-friendly" and forgiving to operators.
- The technique of increasing a tire's contact area by reducing tire pressure to increase traction on snow surfaces is denied to the omnidirectional wheel since it is nonpneumatic.
- The nonpneumatic nature of the omnidirectional wheel, coupled with its high contact pressure (very small contact patch), make it likely that the wheel will suffer excessive sinkage in deep snow, producing a very high motion resistance. Thus, the omnidirectional wheel would probably provide little or no net traction in deep snow. However, on the flight deck of an aircraft carrier, deep snow is unlikely, so this is not considered to be a performance limitation on board a ship.

Based on the results of this study and from my limited exposure to the omnidirectional vehicle and the MD-3, the following recommendations are submitted:

- A well-planned series of tests on thin ice and snow covers, representing that which could be expected on a carrier deck, should be executed if serious consideration of the omnidirectional vehicle continues. Tests on a typical or simulated aircraft carrier deck surface in both a dry and wet condition should also be performed. A single instrumented vehicle or some other conventional vehicle should be used as a control or reference for all tests. Further, the omnidirectional vehicle should be tested in sideways (crabbed) and diagonal driving directions, and braking tests should be performed as well. Full instrumentation, including measurement of wheel rotational velocity, should be employed so that tractive force vs slip curves can be generated, allowing conclusive comparison of the omnidirectional wheel's performance with that of conventional tires.
- Using a softer elastomeric compound in the manufacture of the omnidirectional wheel's rollers would no doubt improve its traction on ice and snow and probably on other surfaces as well. Adding a "tread pattern" to the rollers would probably enhance traction on snow as well.
- The maneuverability advantages of the omnidirectional vehicle must be weighed against its performance in other categories relative to a conventional tire. The possibility of limiting the application of omnidirectional vehicles to the performance of certain functions and/or operations within certain environments may need to be considered.
- The performance of the MD-3 and other flight deck service vehicles could be enhanced on cold regions materials (and no doubt on other surfaces) by replacing the existing bias-ply highway tread tires with all-season radial tires.

ACKNOWLEDGMENTS

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Table 1. End-to-End Dimensions for Butterfly Valves

Valve Size	API 609, MSS SP-68 & MIL-V-24624 Standards: High Pressure Series Class 150	300	600	Low Pressure Series** ANSI Class 125/150	MSS SP-67 Standard: Double Flanged-End Valves: Narrow Series	Wide Series	Single Flange (Lug) & Flangeless (Wafer): Narrow Type C-1 & D-1	Narrow Type C-2 & D-2	Wide Type C-1	Wide Type C-2	AWWA Standard C-504: Short Body	Long Body	Wafer	MIL-V-22133C (Cancelled): Rubber Seated	Metal Seated
1.5	—	—	—	—	—	—	1.31	1.38	1.44	1.55	—	—	—	—	—
2	—	—	—	1.69	—	—	1.69	1.75	1.75	1.81	—	—	—	1.75	1.62
2.5	—	—	—	1.81	—	—	1.81	1.88	1.94	2.00	—	—	—	1.88	1.75
3	1.88	1.88	2.12	1.81	5.00	5.00	1.81	1.88	1.94	2.00	5.00	5.00	2.00	1.88	1.75
4	2.12	2.12	2.50	2.06	5.00	7.00	2.06	2.12	2.19	2.25	5.00	7.00	2.25	2.12	2.00
5	—	—	—	2.19	5.00	7.50	2.19	2.25	2.50	2.56	—	—	—	2.25	2.12
6	2.25	2.31	3.06	2.19	5.00	8.00	2.19	2.25	2.75	2.81	5.00	8.00	2.81	2.25	2.12
8	2.50	2.88	4.00	2.38	6.00	8.50	2.38	2.50	2.81	2.94	6.00	8.50	2.94	2.50	2.37
10	2.81	3.25	4.62	2.69	8.00	15.00	2.69	2.81	3.00	3.12	8.00	15.00	3.12	2.81	2.68
12	3.19	3.62	5.50	3.06	8.00	15.00	3.06	3.19	3.25	3.38	8.00	15.00	3.38	3.19	3.06
14	3.62	4.62	6.12	3.06	8.00	16.00	3.06	3.19	3.62	3.75	8.00	16.00	3.75	3.75	3.62
16	4.00	5.25	—	4.00	8.00	16.00	3.12	3.25	4.00	4.12	8.00	16.00	4.12	4.15	4.00
18	4.50	5.88	—	4.50	8.00	16.00	4.00	4.12	4.50	4.62	8.00	16.00	4.62	4.62	4.50
20	5.00	6.25	—	5.00	8.00	18.00	4.38	4.50	5.00	5.12	8.00	18.00	5.12	5.12	5.00
24	6.06	7.12	—	6.06	8.00	18.00	—	—	6.06	6.19	8.00	18.00	—	—	—
30	—	—	—	6.75	12.00	22.00	—	—	—	—	12.00	22.00	—	—	—
36	—	—	—	—	12.00	22.00	—	—	—	—	12.00	22.00	—	—	—
42	—	—	—	—	12.00	24.00	—	—	—	—	12.00	24.00	—	—	—
48	—	—	—	—	15.00	26.00	—	—	—	—	15.00	26.00	—	—	—
54	—	—	—	—	15.00	28.00	—	—	—	—	15.00	28.00	—	—	—
60	—	—	—	—	15.00	30.00	—	—	—	—	15.00	30.00	—	—	—
66	—	—	—	—	18.00	34.00	—	—	—	—	18.00	34.00	—	—	—
72	—	—	—	—	18.00	36.00	—	—	—	—	18.00	36.00	—	—	—

* See footnotes contained in tables of API 609, MSS SP-69, and AWWA C-504 and MIL-V-22133C (cancelled) standards for additional information on use of Flange gaskets and "installed" dimensions. All dimensions are in inches.

** Applicable to API 609 only.

known as rubber-lined) and high-performance butterfly valves (HPBV). Although these two categories of butterfly valves seem alike, in most instances the rubber-seated butterfly valves can be readily (visually) recognized by the fact that they do not have an adjustable stem-stuffing box and they are installed between pipe flanges without any gaskets.

Rubber-seated Butterfly Valves

Development background

Butterfly valves, in the form of dampers, have been used as flow control devices for centuries. In early devices, the valve 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. With the advent of natural rubber and, later, synthetic rubber liners in the 1950's, the rubber liners (see Figure 1) were used as the seating material to close the gap between the disc edge and the pipe, or valve body, and the damper became a tight-sealing valve.

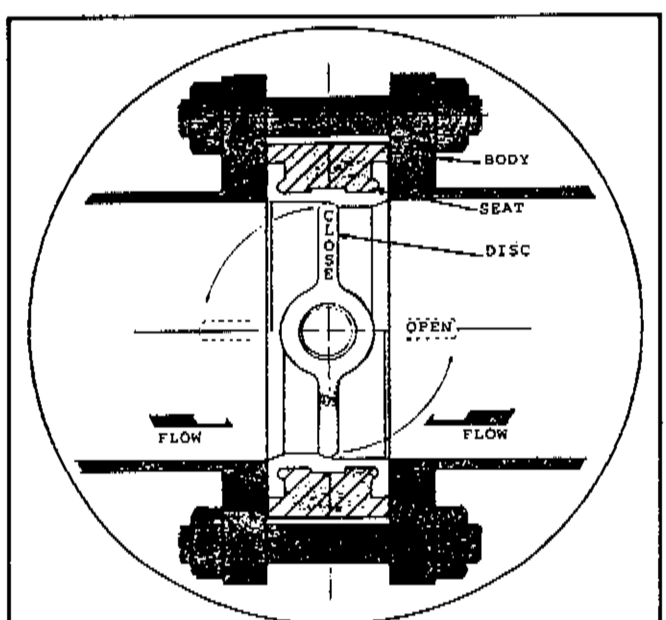

Figure 1. A typical rubber-seated butterfly valve (wafer style).

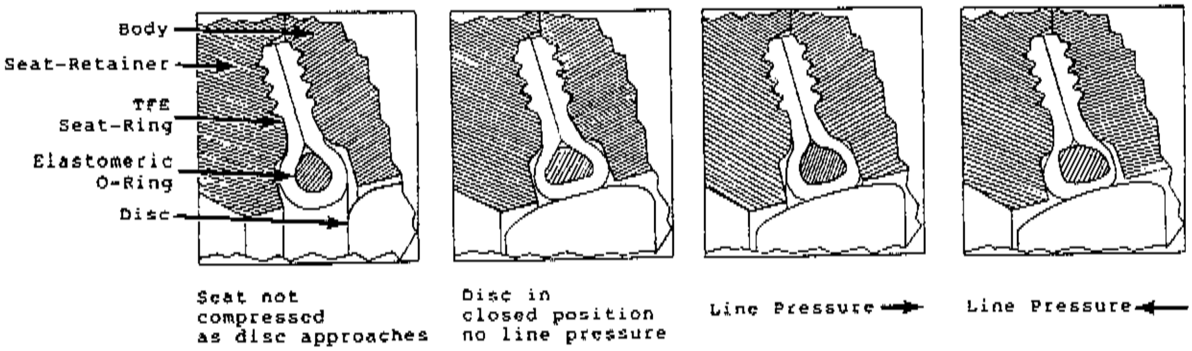

Figure 2. How a High Performance Butterfly Valve seals tight in both directions.

In the earlier valve designs, 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-seat leakage at these points was a common problem. The rubber liner at these points is especially subjected to excessive wear during the entire disc rotation. In the early 1960's, the problem was corrected by offsetting 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 degrees.

The rubber-seated valves can be further subdivided as follows:

a. Industrial rubber-seated butterfly valves

These valves are made to a number of standards, including, Manufacturers Standardization Society (MSS), Standard SP-67; American Petroleum Institute (API), Standard API 609 Low Pressure Series; American Standards Institute (ANSI) Standard ASME/ANSI B16.10, and Mil-V-22133C (now canceled).

Usually offered in cast iron, aluminum, and aluminum bronze body materials, these valves are normally recommended with ANSI rating of class 150 for services requiring pressure differentials below 275 psi and temperatures under 300 degrees F. This type of valve makes up the largest segment of the total butterfly valve market and is usually offered at the lowest price.

b. American Water Works (AWWA) butterfly valves

These valves are made to Standard ANSI/AWWA C-504 and are furnished in varying body types and pressure classes with different end-to-end dimensions. AWWA standards specify body and stem materials, minimum stem diameters, as well as several other design parameters.

Though usually limited to water and sewage services, these valves are occasionally specified for other applications. They are supplied in smaller sizes as rubber-seated valves with extra large diameter stems, and in larger sizes — up to 72 inches — with adjustable sleeves. These valves are generally limited to 25, 75, and 150 psi pressure differentials, depending upon the pressure class designations listed in the standard.

High-performance Butterfly Valves (HPBV)

These valves are made to basically identical standards, such as Manufacturers Standardization Society (MSS), Standard SP-68 and American Petroleum Institute (API), Standard API 609, High Pressure Series; and MIL-V-24624.

Development Background

The soft rubber liners in rubber-seated valves seal by allowing the edge of the disc to compress the rubber seat, producing a local seat contact pressure higher than the line pressure. To seal against higher pressures, the edge of the disc would have to severely compress the rubber liner, resulting in high operational torque and destructive wear of the liner. Left in the closed position for an extended period of time under high 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 — a common complaint with rubber-seated valves.

The latest and somewhat more expensive entry to the butterfly valve market, the HPBVs, are rather sophisticated valves that use a pressure-energized (pressure activated) tetra-fluoro-ethylene (TFE) seat (see Figure 2). The development of TFE offered a material with many desirable properties, such as chemical inertness, low operational torque, and high temperature and high pressure capability for valve seals and seats. However, since TFE is not as resilient as rubber, it could not be directly substituted for rubber without further development.

The HPBVs 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

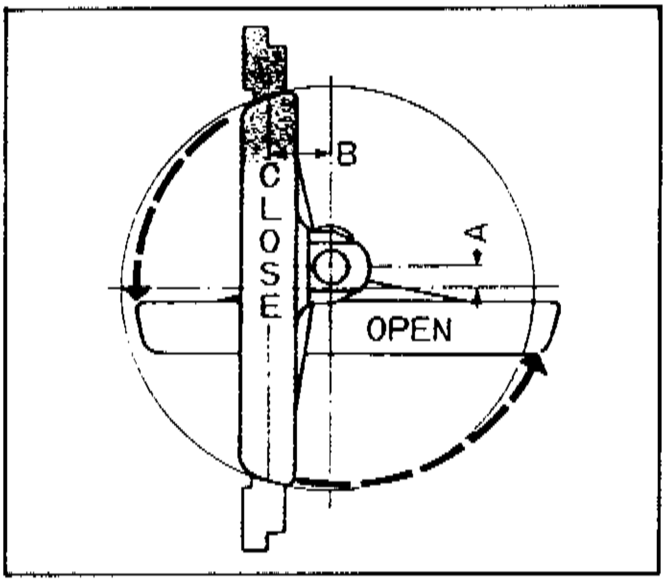

Figure 3. High Performance Butterfly Valve double offset mechanism.

This allows friction-free contact between the body and the seat. Since the rotation axis (stem) of the valve disc is shifted from the center by a distance of the width of A and B, a cam effect is produced which prevents wearing of the seal surface, lessens seating torque and offers longer service life and easy operation.

seats when closed. Furthermore, to minimize the possibility of permanent set of the TFE seat (localized set, adjacent to the valve stem, when the valve is left open for extended periods of time), most HPBVs employ a double offset stem-to-seat design (see Figure 3). This design provides a camming action which, in the fully open position, completely removes the disc from any contact with the TFE seat.

These developments have transformed the butterfly valve into today's HPBV which can be used for pressures up to 1480 psi and beyond.

Since there are over a dozen manufacturers of HPBVs in the USA, and many more overseas, it should be noted that not all HPBVs are properly designed, because the secret of its success lies primarily in the seat design. A properly designed seat should provide bi-directional, tight shutoff, sealing drop-tight at high as well as low pressure differentials. It should also provide a low operating torque, should be self-cleaning (not become packed with suspended solids in the fluid), and perform its required functions within the normal pressure/temperature ratings of the valve.

It should be noted here that unlike the rubber-seated butterfly valves, HPBVs need two additional flange gaskets to seal against the companion pipe flanges, so the installed end-to-end dimensions of HPBVs should include the additional thickness of the two gaskets. The rubber-seated butterfly valves have the rubber liner extended on both sides of the valve, and generally do not require additional flange gaskets.

HPBVs are specified for throttling and tight shutoff applications in full ANSI ratings of class 150 (285 psi max.), class 300 (740 psi max.) and class 600 (1480 psi max.) at relatively higher temperatures compared to the rubber-seated butterfly valves mentioned earlier. Temperature capability ranges up to 400 degrees F, although pressure ratings are significantly reduced at higher temperatures. Recent developments have also been made in bearings and stem seals of HPBVs — all of which have made it possible to achieve reliable valve operation through 100,000 or more valve cycles. The use of exotic body and trim materials — such as SS 316, SS 17-4 PH, Alloy 20, Monel and aluminum bronze — have extended HPBV valve use into many corrosive applications.

Further HPBV developments have resulted in versions which are fire-tested for flammable liquid service,

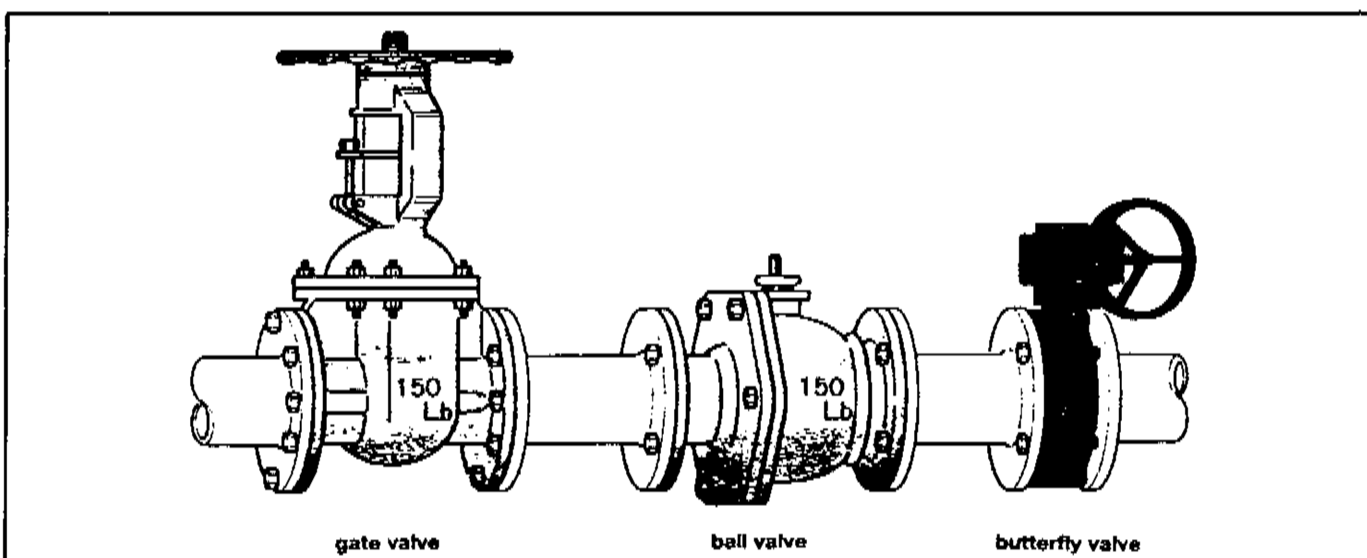

Figure 4. Butterfly Valve compared with gate and ball valves (comparison of envelope sizes).

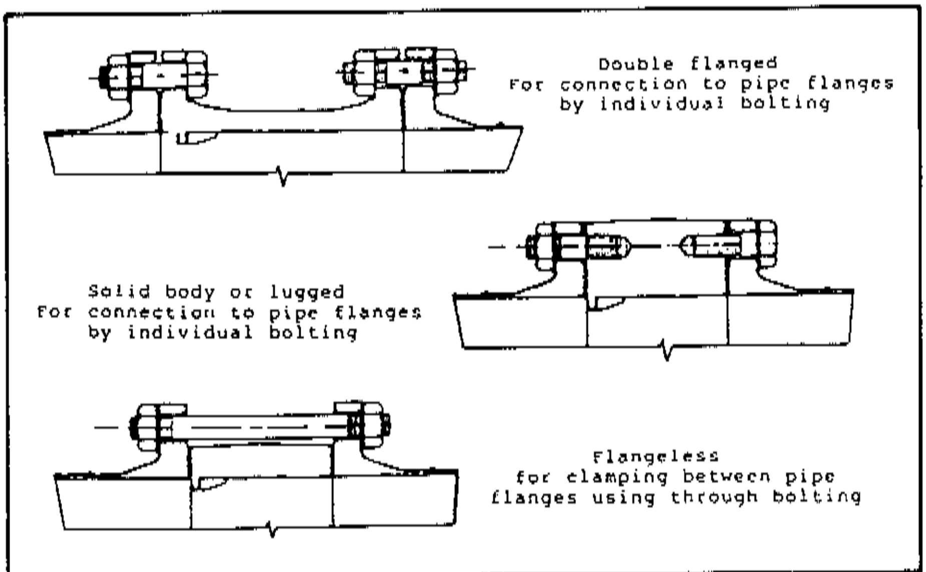

Figure 5. Typical Butterfly Valve end connections.

verisons for cryogenic services at −320 degrees F, and high temperature metal seats; although their success in these areas has been somewhat disappointing.

Butterfly valves are specified with the following end connections (see Figure 5):

a) Wafer style (also called Flangeless style),

b) Lug style (also called Solid body, or Single-Flanged style?, or

c) Double-flanged style (rubber-seated valve only)

The Wafer style, which weighs less and is less expensive, is intended for clamping between the companion pipe flanges using through bolting. These bolts center/align the valve between the pipe flanges by straddling the circumference of the valve body.

The lug style is primarily specified for closure in dead-end piping when installed against a single pipe flange. Such conditions may also occur after removing the pipe flange and piping from one side of the valve during inspection and repair of the components downstream of the butterfly valve. This Lug style valve has every flange bolt hole threaded in the valve body and is connected to the companion pipe flanges by individual bolting to each end of the pipe flange, and does not require the use of nuts. This permits easy removal of one side of the companion pipe flange without disturbing the butterfly valve in the pipe line.

The double-flanged style is similar to the lug style, except that each end of the valve flange is drilled through and is connected to the companion pipe flanges by individual bolts and nuts.

JUSTIFICATION FOR USE:

The manufacturers of butterfly valves tout a number of reasons for using butterfly valves as replacements for gate, globe, plug or ball valves, some of which are detailed below:

- Butterfly valves are significantly lower in cost compared to other types of valves on the market today. This cost differential can be substantial for 6-inch or larger valves.
- A related cost advantage is that the compact size (see Figure 4) and light weight of a butterfly valve (especially beneficial on ships), resulting from its smaller end-to-end dimensions translates into lower installation cost. A maintenance crew can install or replace a 16-inch butterfly valve without using mechanical lifting equipment.
- A relatively lower operational torque requirement allows the use of smaller, less expensive, quarter-turn actuators. In particular, TFE-seated HPBVs have considerably lower torque requirements, because TFE is an extremely slippery material compared to rubber.
- Further economics are possible since the lower weights of the butterfly valve and the required actuator allow the use of reduced pipe hanger supports.
- Because of their inherently approximately "equal percentage" flow characteristics, as differentiated from the "linear" or "quick-opening" flow characteristics of some other valve types, the butterfly valves are often a good candidate for throttling and flow regulation service.
- The stem packing in butterfly valves can be replaced without the stem and disc disassembly, and in many cases, without removing the valve actuator. Further-

more, the seat, particularly in HPBVs, can be easily replaced by simply unscrewing the valve seat retainer socket head cap screws and inserting a new seat.

PROBLEMS

With all the advantages of using butterfly valves, there are some drawbacks. Most of the complaints can be traced to three major areas:

(1) Improper specification of a butterfly valve for a service when a traditional valve would perform better,
(2) faulty butterfly design and/or manufacture, or
(3) improper installation.

Due to one or more of these oversights, the following problems may be encountered:

- *Throttling:* Butterfly valves are routinely specified as control valves for varying the flow when the system demands. However, the following should be noted:

  a) When controlling flow, unlike gate and globe valves, butterfly valves perform as "high pressure recovery valves" — meaning that at higher pressure differentials, the butterfly valves are prone to severe cavitation damage (along with pipe vibrations and noise) to the valve and downstream piping. To avoid such damage, the upper threshold limit of the high pressure differential — which varies with the disc opening — must be obtained from the valve manufacturer. Such data is often omitted from the manufacturers' catalogs.

  For pressure drops exceeding the capabilities of a single butterfly valve, consider using two butterfly valves in series to distribute the drop between the two valves. For severe pressure drops, other type of valves such as globe valves, or speciality throttling valves, should be considered.

  b) Throttling in butterfly valves imposes an involuntary rotation of the valve stem — a phenomenon resulting from the imposed "dynamic torque" on the disc due to the flowing line media. At high differential pressures, this dynamic torque can produce a severe jerk of the valve handle, such that an operator caught off-guard could receive severe injuries.

  c) Throttling in the near closed position (80 degrees or more rotation from the full open position) should not be permitted as this may lead to severe erosion of the soft seat, or possibly the disc itself. In this position, extremely high flow velocities are developed in the valve, and the suspended solids in the line medium have a devastating effect on the valve seat or the disc itself — this phenomenon is often termed "wire drawing".

- *Flange gasket leakage:* HPBVs suffer an inherent design drawback of not providing adequate flange gasket sealing area on the seat retainer side of the valve resulting in flange gasket leakage. The seat retainer encapsulates the TFE seat and is bolted to the valve body, generally by using socket head cap screws. These bolts penetrate the seat retainer in the flange gasket area, and in many valve designs, they rob almost two-thirds of sealing area of spiral-wound gasket. In some situations, where the seat retainer is flush with the body face, the outside diameter of the seat retainer cuts into the gasket sealing area, leaving an inadequate, "skimpy" sealing area.

  The flange gasket sealing problem is further compounded by the fact that the wafer style butterfly valves, if not installed with a perfectly centered seat retainer in the pipe line, will cause flange gasket leakage. As noted earlier, this style of valve does not have flange holes drilled in the valve body, which could have been used as guide holes to align the valve in the pipe line. In addition to the problem of causing flange gasket leakage, the misaligned valve disc can be damaged in the event it strikes the pipe wall inside diameter when the valve is opened.

  A solution to this problem would be to select only those valve designs which have at least 66 percent uninterrupted gasket area in the vicinity of the seat retainer screws to ensure adequate flange gasket seating area. Furthermore, special attention should be paid to the installation of wafer style valves. These valves may be centered by measuring the outside diameters of the seat retainer and the companion pipe flange with a vernier caliper, splitting the difference of the two diameters in half, and subsequently installing the valve by maintaining this difference all around the seat retainer with respect to the pipe flange.

  Another solution to the alignment problem in wafer style valves is to specify valve designs which have at least two diagonally opposed precision-machined (not cast, because casting tolerances can be loose) flange bolt holes in the valve body which can be used as guide holes. Some manufacturers are presently offering this feature in their wafer style valves.

  A third solution is to use custom-cut "over size" flange gaskets to provide enough forgiveness allowance to tolerate any such misalignment. A rule of thumb is to specify the gasket outside diameter slightly larger than the pipe flange raised face outside diameter, and the inside diameter equal to the inside diameter of the pipe.

- *Through-seat leakage:* As noted earlier, the rubber liner in the rubber-seated butterfly valves, when left closed for extended periods of time, tends to deform permanently, taking a set. This results in reduced compression of the rubber, and reduced contact stress between the rubber seat and the disc which leads to through-seat leakage.

  HPBVs perform better in containing a through-seat leak, because their sealing is due to the pressure energizing of the TFE seat by the line media, providing the seat is properly designed. Theoretically, the higher the line pressure, the better the seal. However, the TFE seat material which is less resilient compared to the rubber seat can also take a permanent set or extrude, especially at high pressure differentials, if the seat design does not permit a properly contained set in the body/seat retainer cavity.

  Another through-seat leakage problem of butterfly valves lies in their inherent design. In the valve open position, the disc is always lying in the middle of the line medium, and is subject to the constant bombarding of its sealing surface by the suspended particles in the line medium. When the valve is kept open for long periods, these suspended solids eventually pit or damage the disc sealing surface. When the pitted disc is rotated against the soft TFE seat, the seat gets scratched and nicks may be formed.

Even a hairline scratch may be enough to cause an unacceptable leak. For these reasons, butterfly valves should not be specified in slurry service. It is interesting to note that compared to HPBVs, the rubber-seated butterfly valves are often less prone to disc pitting because the rubber has inherently more elasticity compared to TFE and it tends to conform to the disc surface irregularities.

- *Travel stops:* Butterfly valves, in general, need 90 degree (quarter-turn), clockwise rotation of valve stem to operate. It is important that the disc travel, which is factory "set" for "open" and "close" positions, be maintained at all times.

  In HPBVs, the disc, when rotated, also cams sideways, and if rotated beyond the factory set limits of 90 degrees, can ruin the soft TFE seat. Typically, external travel stops which restrict such stem rotation are mounted on the valve body, adjacent to the stem handle (lever). Such stops may also be provided in the valve-actuator itself. Extreme care should be taken to maintain the designated rotational limits when carrying out field modifications to the valve-actuator assembly. . . . the most common omission is when the valve and actuator are bought separately, and someone forgets to set the travel stops. This setting must be done before the valve is installed in the pipe line — it is often difficult to correct the mistake after the valve is installed.
- *Valve Actuation:* There is no industry standardization of actuator mounting arrangement on valves . . . the actuator and valve mounting bolt patterns differ among manufacturers. The stem diameters and the valve operating torque requirements for a given valve size in its pressure class also vary. For such reasons, valves and actuators from different sources are not interchangeable, and special mounting brackets and stem couplings are necessary.

  Another actuation problem is that the published catalog torque requirements of butterfly valves (and most other types of valves in general) and the torque output of actuators are based upon using brand-new units, installed in clean line media. The typical line medium often contains suspended particles which demand higher operating torques.

  With passage of time, the wear in the valve/actuator bearings, the corrosion of stem and disc, and the deterioration of stem packing and lubricants in the actuator housing, lead to an increase in valve torque requirements, and a decrease in the actuator torque output.

  As such, it is paramount that an adequate safety margin in torques (1.5 or up) be provided to insure that the valve operation is not degraded. It is advisable to buy the valve and actuator as a single package from the same manufacturer, so that the responsibility of selecting and mounting the proper actuator lies with the manufacturer who is generally aware of the problem.

  The torque requirements of HPBVs are usually lower (up to 40 percent less) when the valve is installed with the seat retainer facing the high pressure side of the flow. If bi-directional flow is not required, this feature of lower torque can be used to the advantage of selecting a smaller sized actuator by installing the valve for this preferred direction and ensuring that an appropriate flow-direction arrow is attached to the valve body. Manufacturers' catalogs often publish separate torque data — with the seat retainer facing upstream, and the seat retainer facing downstream of flow.
- *Stem blowout:* It is extremely important that the valves be procured with the stem blowout protection feature. In the remote possibility of internal stem breakage, the line medium will tend to expel the broken stem piece with a force, that, if not contained, can lead to damage to the surrounding equipment and/or possible injuries.
- *Incompatible end-to-end dimensions:* As noted in Table 1, there are differences in laying end-to-end dimensions for butterfly valves procured to various styles and standards. This can pose serious problems when a replacement of one valve with another valve of a different standard is desired. It is too expensive to cut the pipe, or to bring the two pipe flanges together to increase or decrease the required laying lengths to fit another valve of a different end-to-end dimension. For this reason, valve specification engineers are somewhat reluctant to upgrade an existing butterfly valve with another butterfly valve of better performance.

PROBLEMS REPORTED BY THE NAVAL FLEET:

Most of the problems reported by the fleet are associated with the usage and drawbacks of the rubber-seated butterfly valves. Most notable problems have been:

- The fleet has many "older design" rubber-lined valves where the stem penetrates the rubber liner — the seat eventually starts leaking around the penetration area.
- No travel stops are provided in the valve body — it is very easy to turn the disc 180 degrees out of rotation and start a through-seat leak.
- Sailors are accustomed to removing and servicing the actuators mounted on the traditional gate and globe type valves, under line pressure, without ever worrying about stem ejection from the valve body. Most older butterfly valves do not have the stem blowout protection feature. If the line is not depressurized, the stem under fluid pressure will blow out if the actuator or the thrust plate is removed. Most sailors are not aware of this subtle dangerous situation. Casualties resulting from stem blowouts have been reported.
- Almost all rubber-seated butterfly valves use a two-piece stem design. Some designs allow the lower stem piece to penetrate the valve body, having a ferrous pin to retain the stem in place. The integrity of the pin can not be easily inspected — when the pin fails, the lower stem piece can be ejected.

As mentioned earlier, properly designed and installed HPBVs can overcome many of the problems. The Navy's policy since 1985 has been to require HPBVs on all new ship construction. The older rubber-seated butterfly valve specification (MIL-V-22133) has been canceled and a new specification (MIL-V-24624) on HPBV has been issued. The rubber-seated butterfly valves are gradually being replaced by HPBVs especially in hazardous systems and in areas where rubber-seated valves have been a chronic maintenance and operating problem.

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 applications for butterfly valves.