American Journal of Industrial Engineering, 2018, Vol. 5, No. 1, 36-40
Available online at http://pubs.sciepub.com/ajie/5/1/6

DOI:10.12691/ajie-5-1-6

Why are Butterfly Valves a Good Alternative to Ball Valves for Utility Services in the Offshore Industry?

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Received August 08, 2018; Revised October 12, 2018; Accepted October 29, 2018

Abstract Ball and butterfly valves are quarter-turn type valves that are widely used in the oil and gas industry for stopping and starting (isolation and opening) of the flow of fluid. Ball valves have a very robust design and they are a very common choice for aggressive process services involving flammable and possibly toxic fluids such as hydrocarbons. On the other hand, butterfly valves are lighter, more compact, and cheaper than ball valves, so they are a good choice for non-aggressive services such as water, oxygen, etc. Butterfly valves are not as robust as ball valves in process services, and therefore require higher maintenance costs. This paper aims to focus on the characteristics that make butterfly valves more suitable than ball valves in utility services. The parameters discussed are face-to-face, weight, and torque. Torque is a measure of how much force can act on a valve operator to rotate the valve closure member to be opened or closed. A comparison of the face-to-face (length) of ball and butterfly valves in Class 150 (pressure nominal 20) and size ranges of 4" to 20" shows that butterfly valves are approximately 84% more compact than even short pattern ball valves. It should be noted that utility services are mainly found in low pressure classes such as Class 150. Also, butterfly valves are not recommended to be used in sizes less than 4" due to pressure drop. The weight comparison between ball and butterfly valves in the above-mentioned size and pressure class shows that butterfly valves are approximately 75% lighter than ball valves. The last part of this paper compares the torque values and actuator size of 10" Class 150 butterfly and ball valves. The torque values of the butterfly valve are lower than the torque values of the ball valve, which leads to a more compact actuator, a mechanical device installed on the top of the valve for automatic operation. In fact, there is much space limitation on offshore platforms compared to onshore units. Additionally, offshore platforms have limited weight capacity so it is an advantage to save space and weight on the platforms through selecting a lighter and more compact valve.

Keywords: *butterfly valves, ball valves, oil and gas industry, offshore*

Cite This Article: Karan Sotoodeh, "Why are Butterfly Valves a Good Alternative to Ball Valves for Utility Services in the Offshore Industry?" *American Journal of Industrial Engineering*, vol. 5, no. 1 (2018): 36-40. doi: 10.12691/ajie-5-1-6.

1. Introduction

Valves are mechanical devices specially designed to direct, start, stop, and mix or regulate the flow, pressure, or temperature of a process fluid. By the nature of their design and handling of process fluids, valves are categorized in three areas: *on-off valves*, which block fluid or allow it to pass; *non-return* valves, which only allow flow to travel in one direction; and *throttling valves*, which allow for regulation of flow at any point between fully open and fully closed [1]. Common on-off valves include ball, butterfly, plug and gate valves. Ball valves have a robust design that makes them suitable for corrosive process fluids such as hydrocarbons. Additionally, ball valves are quarter turn valves, which mean that the valve closure member is moving between the open and closed positions through 90° rotation [2,3].

Butterfly valves have become popular because they are more compact and lighter than gate or globe valves. Wafer and lug designs are favourite body styles for valves in some size ranges from 2" to 12". [3] Butterfly valves, which are quarter turn like ball valves, have advantages over ball, gate, and plug valves such as saving weight, space, and cost, as well as required torque for opening and closing the valve. [4] Figure 1 and Figure 2 show a 20" CL 150 butterfly valve for firefighting water service and a 20" CL150 full bore ball valve in process services with a comparison of the weight and face-to-face values of these two valve types. [4]

A wafer design is defined as a flangeless design with facing that permits installation between ASME and manufacturer standard (MSS SP) flanges. [5] Noticeably, the weight of valves including ball and butterfly valves are different from one valve supplier to another one. However, face-to-face of values of the ball and butterfly valves are usually based on international standards such as ASME and API. [5,6] Wafer type butterfly valves are widely used for utility services (non-aggressive fluids) such as water, sea water, oxygen, etc. in the offshore industry instead of ball valves because of the aforementioned advantages. Wafer type butterfly valves are mainly used for ASME pressure class 150 equal to 20Barg. [7]

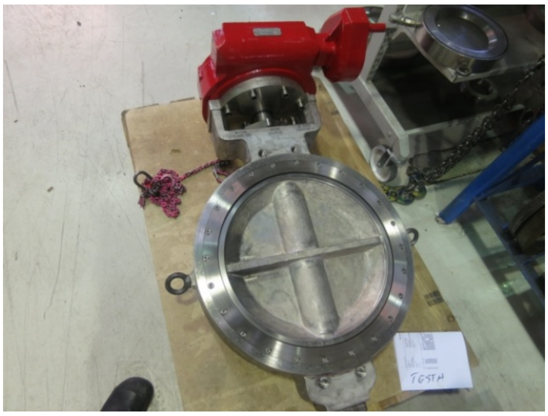

Figure 1. Wafer type butterfly valve, soft seat 20” CL150, titanium body (Face-to-face: 127 mm, Weight: 231 KG)

Figure 2. Full bore ball valve, soft seat 20” CL150, 22Cr duplex body (Face-to-face: 914 mm, Weight: 1569 KG)

The main aim of this paper is to compare wafer type butterfly and ball valve face-to-face, height, weight, torque values, and actuator size in different sizes from 4” to 20” and ASME pressure class 150. An actuator is a mechanical device which is installed on the top of the valve for automatic operation. Figure 3 illustrates a pneumatic actuated ball valve. The values of height, weight, and torque are based on valve manufacturer information and not standard.

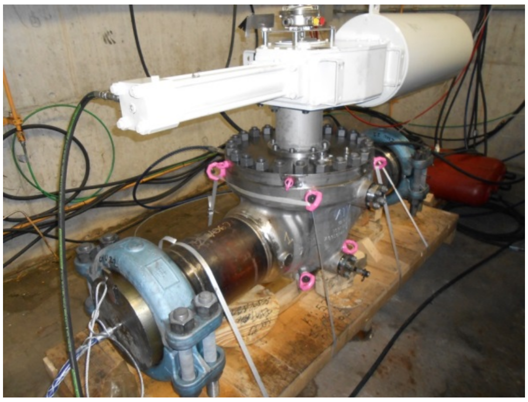

Figure 3. Pneumatic actuated ball valve

2. Ball Valve vs. Butterfly Valve

2.1. Face-to-Face Comparison

Table 1 contains face-to-face values of the ball (short and long patterns) and butterfly valves in pressure class 150 from 4” to 20”size ranges. ASME B16.10, *Face-to-Face and End-to-End Dimensions of Valves*, and API 609, *Butterfly Valves: Double Flanged Lug and Wafer* are standards for face-to-face dimensions of the ball and butterfly valves, respectively. Two categories of butterfly valves are included in the API 609 standard. Category A is the concentric disk and seat configuration and Category B has an offset disk configuration [5] that is known as an eccentric butterfly valve or high-performance butterfly valve. [8]

A category B double offset butterfly valve in wafer design will be compared here to a ball valve. A category B butterfly valve was selected for comparison because this type of valve is more robust and requires less maintenance compared to category A. One disadvantage of butterfly valves is that the disk of the valve is presented to the flow, which creates pressure loss. Additionally, butterfly valves are reduced bore with a lower flow capacity and higher pressure drop compared to ball valves. For this reason, butterfly valves are not recommended for sizes less than 4”. [9]

Figure 4 compares the values shown in Table 1. The chart shows that face-to-face measurements of the butterfly valves in sizes 4” to 20” and pressure class 150 on average are approximately 84% more compact than even short pattern ball valves.

Table 1. Comparison between wafer type butterfly and ball valves face-to-face in mm

Wafer Butterfly Valves Face-to-face (mm), API 609 Cat.B, Class150, Sizes from 4” to 20”								
4”	6”	8”	10”	12”	14”	16”	18”	20”
54mm	57mm	64mm	71mm	81mm	92mm	102mm	114mm	127mm
Ball Valves (Long Pattern)Face-to-face (mm), ASME B16.10, Class150, from 4” to 20”								
4”	6”	8”	10”	12”	14”	16”	18”	20”
305mm	457mm	521mm	559mm	635mm	762mm	838mm	914mm	991mm
Ball Valves (Short Pattern)Face-to-face (mm), ASME B16.10, Class150, from 4” to 20”								
4”	6”	8”	10”	12”	14”	16”	18”	20”
305mm	403mm	419mm	457mm	502mm	572mm	610mm	660mm	717mm

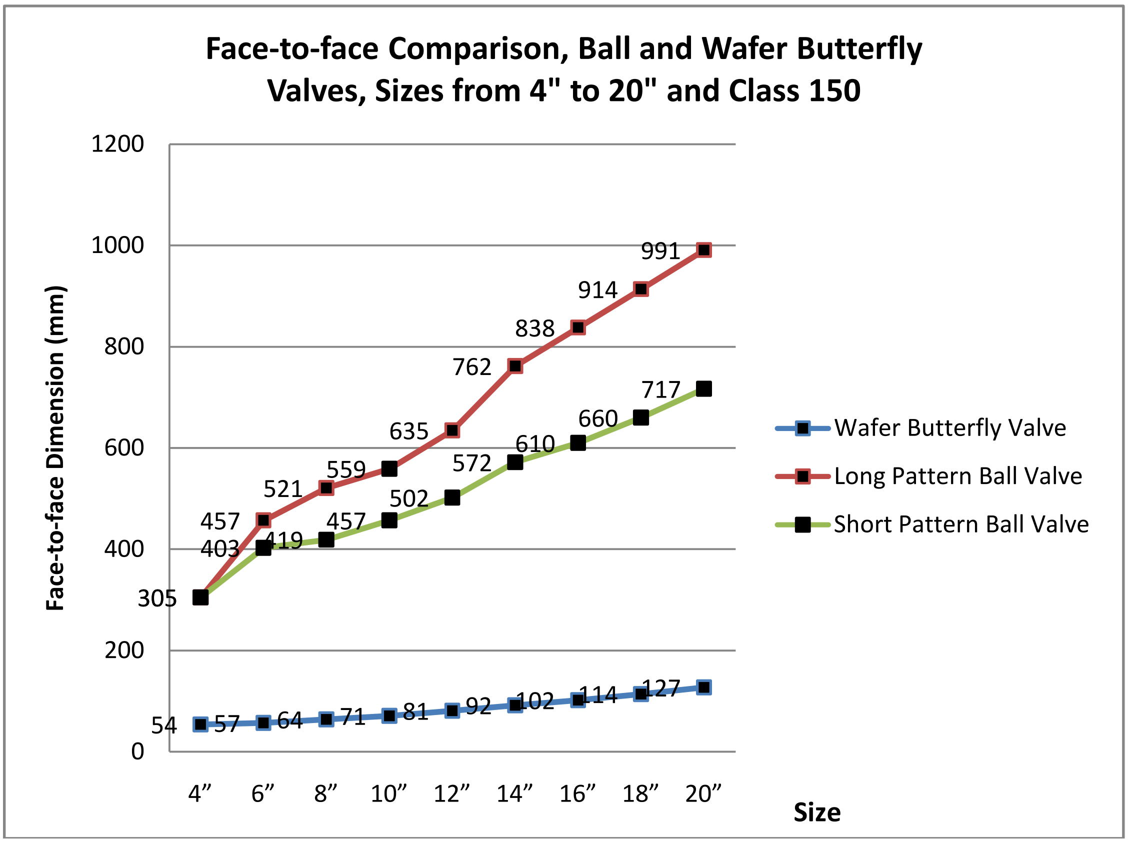

Figure 4. Comparison between wafer type butterfly and ball valves face-to-face

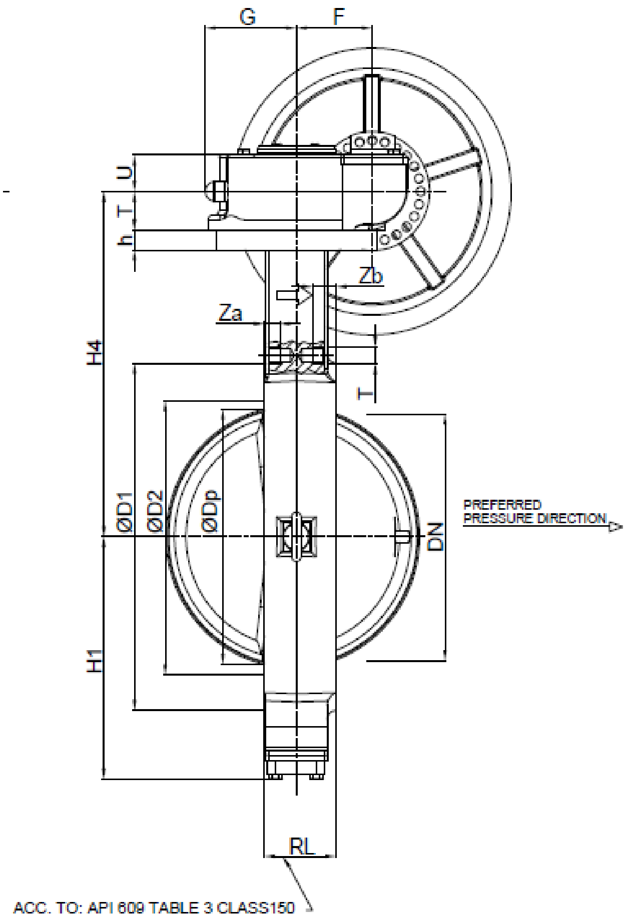

Figure 5. Wafer type butterfly valve general arrangement

2.2. Height Comparison

The butterfly valve is also shorter than a ball valve in the same size and pressure class. The height of the valve is defined as $H1 + H4 - T$ as shown in Figure 5, a general arrangement drawing of a butterfly valve. $H1 + H4 - T$ shows the distance from the bottom of the valve to the top of the valve flange. The height of the valve is based on the manufacturers’ standard. Table 2 provides $H1 + H4 - T$ values for butterfly valves in class 150 for size ranges from 4” to 20”. The average height of a butterfly valve in above mentioned sizes and pressure classes is 628,2mm.

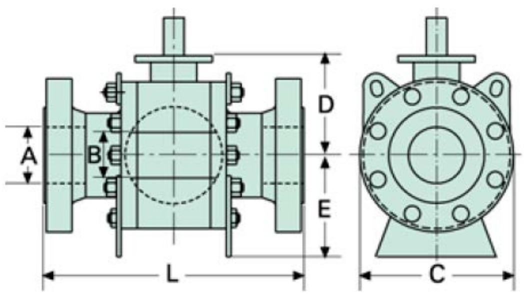

Figure 6. Ball valve general arrangement

The height of the ball valve is equal to $D + E$ in Figure 6—the distance from the bottom support of the valve to the top flange. Table 3 provides $D + E$ values for ball valves in class 150 for size ranges from 4” to 20”. The average height of the ball valve in the sizes and pressure classes mentioned earlier is 641mm. Therefore, the height of a butterfly valve and a ball valve in the same size and pressure class is similar, but in this example the butterfly valve height is less than the ball valve height.

Table 2. Wafer type butterfly valve heights based on manufacturer standards in mm

Wafer Butterfly Valves Height (mm), API 609 Cat.B, Class150, Sizes from 4” to 20”								
4”	6”	8”	10”	12”	14”	16”	18”	20”
362mm	446mm	461mm	528mm	606mm	691mm	770mm	865mm	925mm

Table 3. Ball valve heights based on manufacturer standards in mm

Ball Valves Height (mm), Class150, Sizes from 4” to 20”								
4”	6”	8”	10”	12”	14”	16”	18”	20”
361mm	434mm	504mm	598mm	643mm	708mm	766mm	829mm	926mm

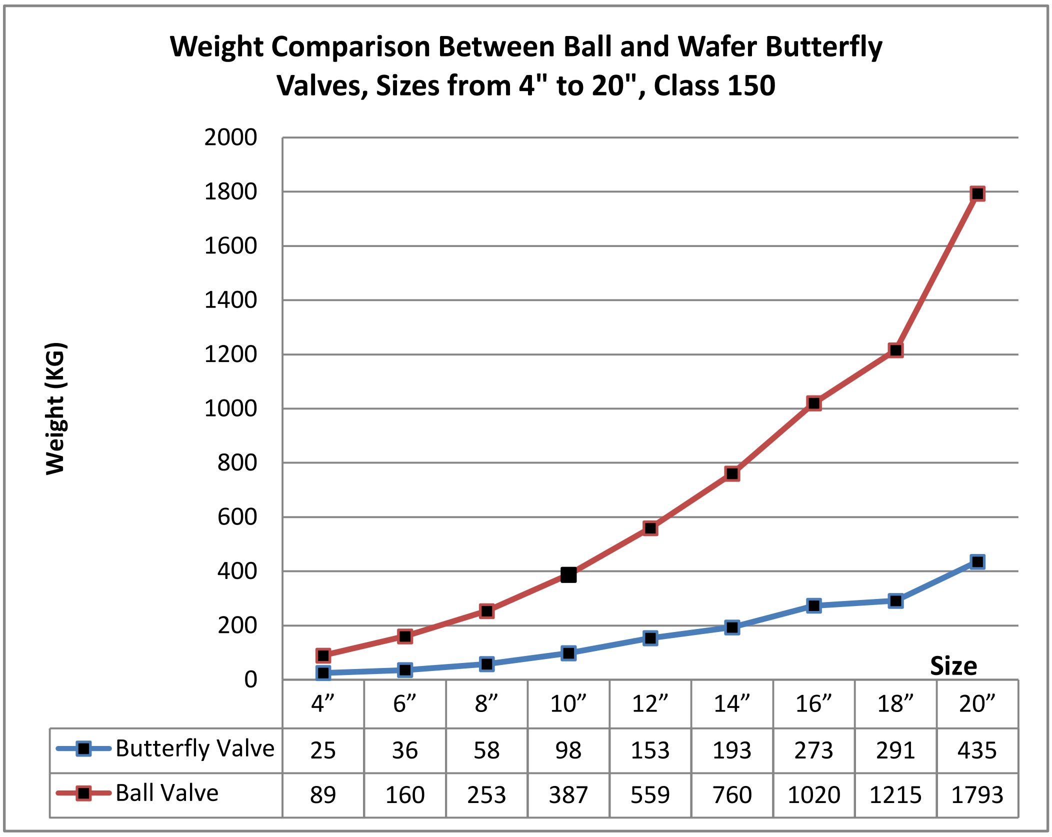

Figure 7. Weight comparison between wafer type butterfly valves and ball valves

2.3. Weight Comparison

Figure 7 compares the weight of a bare stem butterfly valve and a ball valve in size ranges of 4” and 20” and a pressure class of 150. The weights of valves are also based on manufacturer standards. Wafer type butterfly valves in class 150 and size ranges from 4” to 20” are approximately 75% lighter than ball valves with the same size and pressure class, based on the data provided in Figure 7.

2.4. Torque Comparison

Torque is a measure of the force placed on a valve operator to rotate the valve closure member to open or close a valve. The breakaway torque is the maximum thrust or torque required to operate a valve at maximum pressure differential. [10,11] A butterfly valve has a lighter disk (closure member) compared to the ball of the ball valve, so the torque values are lower. Table 4 shows a comparison of the torque values of a 10” butterfly valve Class 150 with a ball valve in the same size and pressure class and safety function. Both valves are usually open and will be closed in case of any failure occurring in the system. Additionally, the effect of torque on actuator sizing of the valve will be evaluated. Torque values are different from one supplier to another. These are the torque values compared in Table 4:

- BTO (Break to Open)
- ETO (End to Open)
- Running
- BTC (Break to Close)
- ETC (End to Close).

Table 4. Comparison of torque values in N.m for 10” Class 150 ball and butterfly valves

Valve torque (N.m)	BTO	ETO	Running	BTC	ETC
10”Butterfly Valve Class 150	585	146.3	293	146.3	527
10”Ball Valve Class 150	1242	1039	837	1217	1039

Table 5. Actuator torque values in N.m and safety factor for a 10" Class 150 Butterfly Valve

Valve Torque (N.m)	BTO	ETO	Running	BTC	ETC
10"Butterfly Valve Class 150	585.0	146.3	293.0	146.3	527.0
Pneumatic Actuator Model X	1463.1	910.2	698.6	1618.1	1145.2
Safety Factor	2.50	6.22	2.38	11.6	2.17

Table 6. Actuator torque values N.m and safety factor for a 10" Class 150 Ball Valve

Valve Torque (N.m)	BTO	ETO	Running	BTC	ETC
10"Ball Valve Class 150	1242	1039	837	1217	1039
Pneumatic Actuator Model Y	7822	4479	3702	6356	3264
Safety Factor	6.3	4.3	3.5	5.2	3.1

The measured torque values are obtained by applying design pressure equal to 20Barg to one side of the valve during the operation. The breakaway torque is BTO for both ball and butterfly valves. The BTO for a ball valve is 2.12 times larger than the BTO for the butterfly valve in this example. The valves are actuated and the next step is to compare the size of the selected actuator for these two valves. An actuator is a mechanical device installed on the top of a valve for automatic operation. Both valves in this example are operated with pneumatic actuators. The safety factor for the actuator in this example is 2.0, which means that the torques produced by the pneumatic actuator in 7Barg air pressure should be at least two times the valve torque values given in Table 4. The most compact actuator, which can produce at least twice the torque values given in Table 4, was selected for the valves based on the torque data in Table 5 and Table 6.

The pneumatic actuator Model Y selected for the ball valve generates more torque and is larger than the pneumatic actuator Model X selected for the butterfly valve. Figure 8 compares the overall dimensions of the pneumatic actuators selected for the ball and butterfly valves. The dimensional values in red are for pneumatic actuator Model X, which is selected for the butterfly valve. The figure shows that the actuator selected for the butterfly valve is more compact.

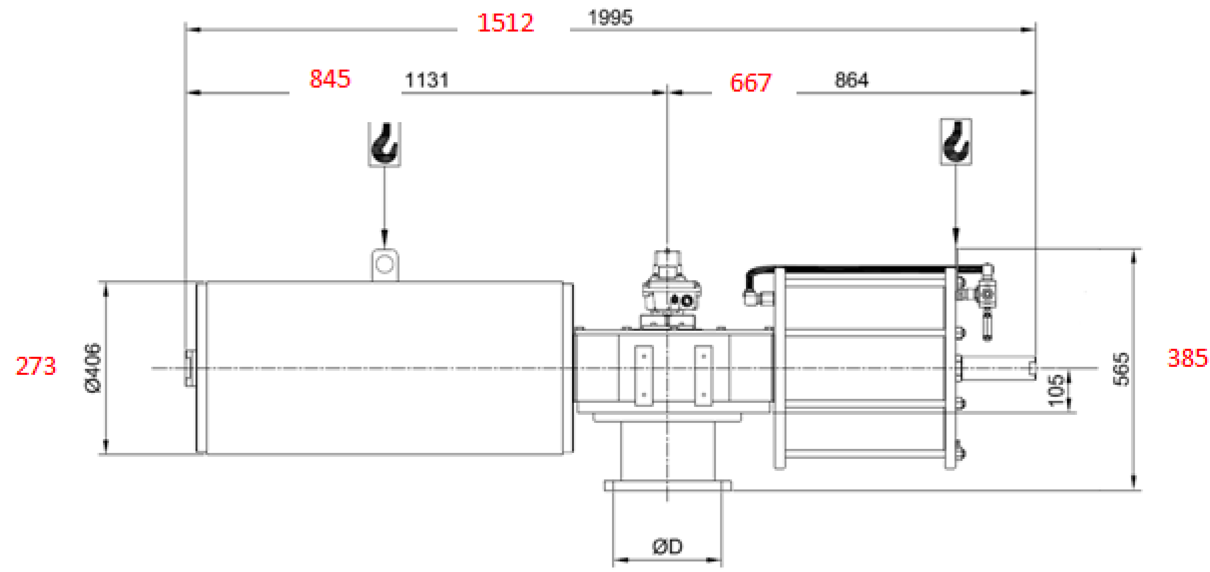

Figure 8. Comparison of pneumatic actuators selected for the ball and butterfly valves (Note: Dimensions are in mm)

3. Conclusion

This paper discusses different reasons to select a butterfly valve instead of a ball valve for utility services. Butterfly valves have more compact face-to-face values and are lighter than ball valves. They also require less torque for operation which leads to savings on actuator space, weight, and cost. In fact, there is much space limitation on offshore platforms compared to onshore units. Additionally, offshore platforms have limited weight capacity so it is an advantage to save space and weight on the platforms through selecting a lighter and more compact valve.

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