RESILIENT SEATED BUTTERFLY VALVES

TECHNICAL SALES MANUAL

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Contents

Torques

INTRODUCTION TO TORQUES

There are a number of torques which butterfly valves may experience such as:

- **T_{su} - Seating and Unseating Torque**
- **T_d - Dynamic Torque Resulting from fluid flow**
- **T_{bf} – Bearing Friction Torque**
- **T_{ss} – Stem Seal Friction Torque**
- **T_e – Eccentricity Torque resulting from disc offset from centerline of stem (either single, double or triple offset)**
- **T_h – Hydrostatic Torque**

Factors which influence the butterfly valve torque values shown above are:

- Type of Seat and Seat Material
- Interference of Seat I.D. and Disc O.D.
- Shaft Diameter
- Valve Diameter
- Bearing Coefficient of Friction
- Angle of Opening
- Shut-off Pressure
- Fluid Velocity
- Disc Shape and Configuration
- Piping System and Location/Orientation of Valve in Pipe Line
- System Head Characteristics
- Physical Size of Disc/Shaft Obstructing Flow
- Disc Edge Finish

With respect to Butterfly Valves, the two major conditions for determining total valve operating torque (T_T) exists as follows:

CASE I (Angle = 0° , Disc in Closed Position)

$$T_T = T_h + T_{bf} + T_{ss} + T_{su}$$

Analyzed

Total Torque for Case I using a symmetrical disc butterfly valve is the sum of hydrostatic torque, bearing friction torque, stem seal, friction torque, and seating/unseating torque.

A. Hydrostatic Torque (T_h)

We will ignore discussion of the hydrostatic torque values as they are generally insignificant compared to the seating/unseating, bearing friction and stem seal torque values (the safety factor applied to seating/unseating, stem seal friction and bearing friction torque values more than compensates for the hydrostatic torque which is usually less than 2% of these total torques).

B. Bearing Friction Torque (T_{bf})

Bearing friction torque occurs because pressure forces against the disc are transmitted to the stem. As the stem is forced against the bearing supports, bearing friction torque is created between the stem material and the support material as the stem is turned. Bearing friction torques are normally included in the seating/unseating torque values.

Bearing friction torques can be determined by using the following equation:

$$T_{bf} = .785\ C_f\ D_v^2\ (d/2)\ \Delta P$$

Where:

- T_{bf} = Bearing Friction Torque
- C_f = Coefficient of Friction (approximately .25 for non-corroded stem to cast iron body) (dimensionless).
- D_v = Valve Diameter (Inches)
- d = Diameter of Shaft (Inches)
- ΔP = Pressure Differential (psi)

C. Stem Seal Friction Torque (T_{ss})

For all practical purposes stem seal friction torque values are insignificant when compared to seating/unseating and bearing friction torques. Stem seal friction torques are normally included in the seating/unseating torque values.

D. Seating/Unseating Torques (T_{su})

The seating/unseating torque value (T_{su}) is a function of the pressure differential, the seat material's coefficient of friction, the finished surface of the disc edge, the amount of interference between the seat I.D. and disc O.D. when flanged in piping, the seat thickness, and the type of service (media) for which the valve is being used. In determining the T_{su} values for Bray resilient seated butterfly valves, Bray has developed Seating/Unseating Torque Charts incorporating all bearing friction and stem seal friction torques for three classes of services for both the valves with standard discs (rated to full pressure) and for valves with reduced diameter discs (rated for 50 psi [3.5 bar]). The three service classes are:

Class A – Non-Corrosive, Lubricating Service

Class B – General Service

Class C – Severe Service

Please review the guidelines for each class in the technical manual when determining which Seating/Unseating Torque Class should be used. Most butterfly valves are used in Class II, General Service applications.

E. Total Torque (T_T)

The total torque values for Bray symmetrical disc valves for Case I applications are shown in the Seating/Unseating Torque Charts within this manual.

CASE II (Disc in Partial To Full Opening Position)

$$T_T = T_{bf} + T_{ss} + T_d$$

The total Torque for Case II using a symmetrical disc butterfly valve is the summation of bearing friction torque, stem seal friction torque and dynamic torque.

A. Bearing Friction Torque (T_{bf})

See Case I discussion. This torque value is normally included in the Dynamic Torque Value.

B. Stem Seal Friction Torque (T_{ss})

See Case I discussion. This torque value is normally included in the Dynamic torque value.

C. Dynamic Torque (T_d)

In a symmetrical disc design, dynamic torque occurs between the closed position, 0° and the full open position, 90°. With the disc in the partially open position, velocity of the fluid passing the leading disc edge is less than the velocity passing the trailing edge. This variance in velocity past the leading disc edge and trailing disc edge results in an unbalanced distribution of pressure forces on the upstream side of the face of the disc. The total pressure forces acting perpendicular to the disc face on the leading edge half of the disc are greater than the total pressure acting perpendicular on the trailing half of the disc. This uneven distribution of pressure on the disc face (exists on both sides of the disc) results in a torsional force which tries to turn the disc to the closed position **(Figure 1)**. This torsional closing force can become greater than the seating/unseating torque value depending on the valve angle of opening and differential pressure.

To determine dynamic torque, the following equation is applied:

$$T_d = C_{dt}\, d^3\, \Delta P$$

Where:

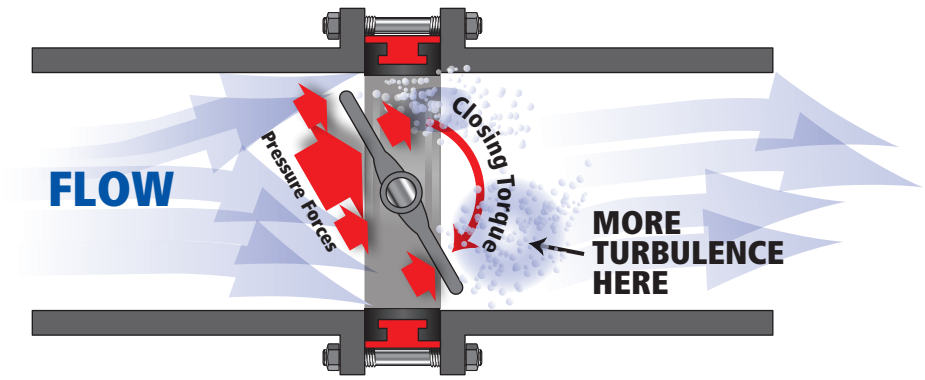
T_d = Dynamic Torque (lbs- in).

C_{dt} = Coefficient of Dynamic Torque (based on disc shape and angle of opening) (dimensionless)

d = Diameter of Disc (Inches)

ΔP = Pressure Differential Across Valve (psi)

Figure 1 - Pressure Distribution



As shown in **Figure 2**, coefficient of dynamic torque for Bray's symmetrical disc valves is at 0° angle of opening and increases until the angle of opening reaches 75°-80°, where it then decreases to a zero value at full open (90°) (no internal friction factors considered, just dynamic torque only).

One final comment about dynamic torque is that one may minimize the dynamic torque by the orientation of the valve (stem horizontal or vertical) in the pipeline as well as by the location (distance) in the pipeline from elbows, other valves, etc. (See Bray Resilient Seated BFV Operations and Maintenance Manual).

D. Total Torque (T_T)

The total torque required for operating a Bray symmetrical disc butterfly valve at an angle opening between 0° and 90° is shown in the Dynamic Torque section of this manual. Note that the dynamic torque includes all internal friction torque values.

CONCLUSION

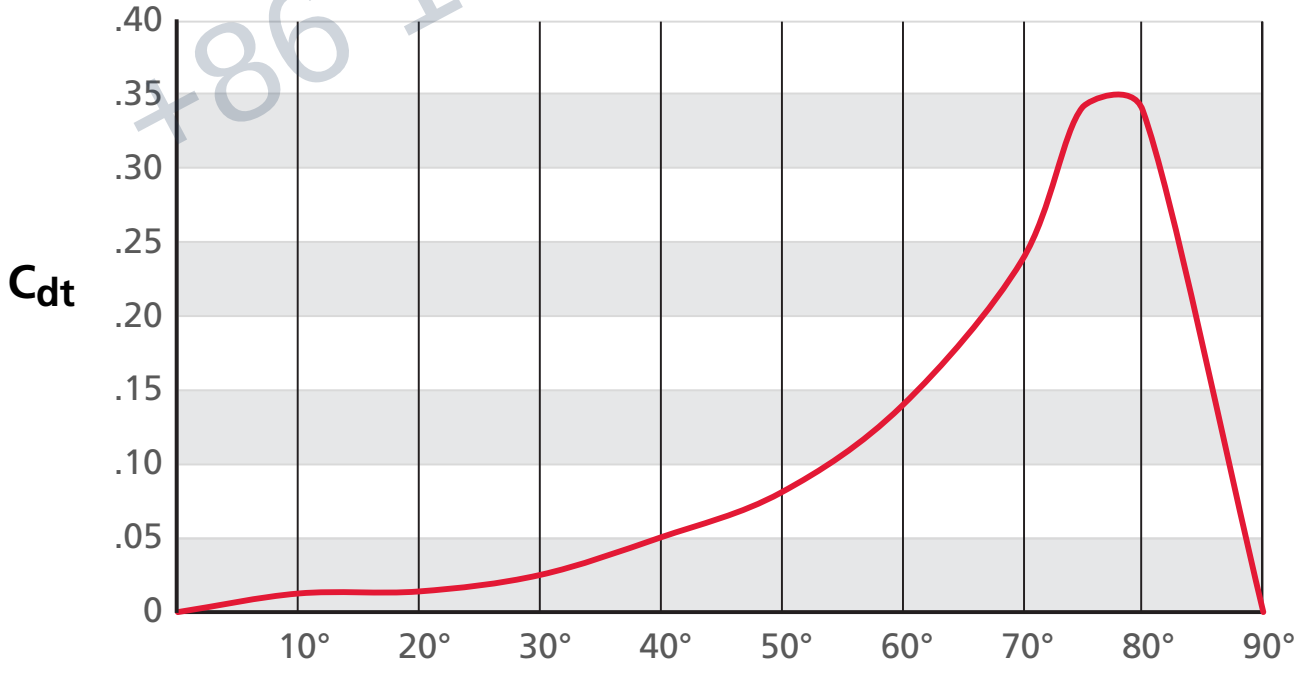
In most applications for butterfly valves, especially 20˝ (DN 500) or smaller, the maximum torque required to operate the valve will be seating/unseating torque. However, dynamic torque should be considered particularly in:

- Control applications using larger valves (24˝ [DN600] and above) where the disc is maintained in the open position
- Applications using larger valves (24˝ [DN 600] and above) where the velocity is high (16 ft./sec [4.9m/sec]).

Figure 2 - Angle of Opening

The C_{dt} value for Bray symmetrical disc valves are approximately:

Angle of Opening	0°	10°	20°	30°	40°	50°	60°	70°	75°	80°	90°
C_{dt}	0	0.0126	0.0140	0.0251	0.0505	0.0809	0.1394	0.2384	0.3419	0.3400	0



REDUCED DISC DIAMETER BRAY SERIES 30/31/3A VALVES

Bray offers a reduced disc diameter for 4"-20" for Series 30, 31 and 3A valves. The purpose of reducing the disc diameter is to decrease the seating/unseating torques and extend the seat life on low pressure applications.

By reducing the disc diameter, the interference between the disc O.D. and seat I.D. is decreased and the valve pressure rating, which is a function of this interference, is reduced to 50 PSI. Less interference between the disc and seat results in reduced seating/unseating torques. Lower seating/unseating torque may allow for the use of a smaller actuator on the valve. In other applications where abrasive dry bulk materials such as cement, sugar, plastic, pellets, flour, etc., are generally pneumatically conveyed at 50 PSI or less, the reduced disc diameter not only reduces the seating/unseating torque but, very importantly, usually significantly increases the service life of the seat.

Bray does the following to differentiate reduced diameter discs from full diameter discs:

Metal Discs: An " R " is stamped above the part number

Nylon 11 Coated Discs: Discs are differentiated by the color of the Nylon 11:

Grey – Full Disc Diameter

White – Reduced Disc Diameter

SEATING & UNSEATING TORQUES

Bray has developed Seating/Unseating Torque Charts for three Classes of Service for its valves with standard discs (rated for full pressure) and for valves with reduced diameter discs (rated for 50 PSI / 3.5 bar.).

The guidelines for selecting a Class to be used for determining a valve's seating/unseating torque are given below. Each valve application should comply with all five Class characteristics in order to be qualified for that Class.

Characteristics of Application	**Class A** Non-Corrosive, Lubricating Service	**Class B** General Service	**Class C** Severe Service
Media Type	Lubricating hydrocarbons; Aqueous processes and Water (See Note 1)	Water; aqueous processes; all other aqueous liquids including salt water; Lubricating gases	Dry, non-lubricating such as air, dry gas, cement, pneumatic conveying mediums
Corrosion by Media	Insignificant if any	No major corrosion or deposits from media	Can incur significant corrosion such as Ductile Iron disc in water
Chemical Reactions of Media with Seat	Insignificant if any	Only minor or insignificant in nature	Reactions causing swelling and hardness occur
Media Temperature	45º to 160ºF (7º to 71ºC)	Within seat temperature limits, not near limits	Near or at seat temperature limits
Frequency of Valve Cycling	Once weekly or more frequently	Minimum once every 3-6 weeks, or more frequently	Infrequently, sometimes not cycled for long periods

NOTE:

1. For aqueous processes and water, Class A torques may be used only if a Nylon 11 coated disc is selected and all other Class A characteristics apply. Otherwise, Class B torques should be used.
2. All the material trims may be classified into Class A, B, or C except Series 20/21 valves with a PTFE Lined Elastomer seat, PTFE molded disc/stem, or rubber molded disc/stem. These trims must always use Class C Seating/Unseating Torque Values unless they are used only in a throttling application. Valves with bonded seats must always be classified as Class C.
3. If a valve is used strictly in a throttling application, that is, it is never put in the closed position but throttled between 20° and 80°, then Class A torques may be used provided you have checked to see that dynamic torques do not exceed the Class A torque values.
4. With the exception of dry, non-lubricating medias, one is usually safe electing to use Class B torques for sizing actuators for all other valve service applications. Seating/Unseating Torque values shown include friction bearing torques for stated differential pressure.
5. Dynamic Torque values are not considered. See the Dynamic Torque chart in this manual for determination of Dynamic Torque.
6. Do not apply a safety factor to torque values when determining actuator output torque requirement.
7. **For 3-way assemblies where one valve is opening and another is closing, multiply torque by a 1.5 factor.**

Series 20/21 and 30/31/3A Torques Imperial (Lb-Ins)

	Valve Size Inches	Valve Differential Pressure (PSIG)						
		Full Disc					Reduced Disc	
		0 psi	50 psi	100 psi	150 psi	175 psi	0 psi	50 psi
Class A Non-Corrosive, Lubricating Service	1	54	59	65	70	73	54	59
	1.5	81	86	91	97	100	81	86
	2	109	114	119	123	128	109	114
	2.5	169	178	187	196	200	169	178
	3	220	236	250	264	273	220	236
	4	341	364	387	410	423	225	248
	5	510	560	610	660	687	324	374
	6	632	712	792	872	912	344	488
	8	1,182	1,341	1,500	1,660	1,741	735	894
	10	1,764	2,018	2,272	2,526	2,653	1,204	1,358
	12	2,701	3,110	3,519	3,928	4,132	1,665	2,074
	14	3,818	4,500	5,182	5,864	—	2,318	3,000
	16	4,638	5,819	7,000	8,182	—	2,699	3,880
	18	5,265	7,065	8,865	10,665	—	2,970	4,788
	20	7,000	9,364	11,728	14,091	—	3,356	6,243
Class B General Service	1	59	65	71	77	80	59	65
	1.5	89	95	100	106	110	89	95
	2	120	125	130	135	140	120	125
	2.5	185	195	205	215	220	185	195
	3	245	260	275	290	297	245	260
	4	375	400	425	450	462	252	267
	5	560	615	670	725	755	355	410
	6	695	783	871	953	1,003	427	537
	8	1,300	1,475	1,650	1,825	1,915	808	983
	10	1,960	2,240	2,520	2,800	2,940	1,213	1,493
	12	2,970	3,420	3,870	4,320	4,545	1,830	2,280
	14	4,200	4,950	5,700	6,450	—	2,550	3,300
	16	5,100	6,400	7,700	9,000	—	2,967	4,267
	18	5,850	7,850	9,850	11,850	—	3,267	5,267
	20	7,700	10,300	12,900	15,500	—	4,267	6,867
Class C Severe Service	1	74	82	89	97	100	74	82
	1.5	111	119	125	133	137	111	119
	2	151	157	163	169	175	151	157
	2.5	231	244	257	269	275	231	244
	3	306	325	344	363	375	306	325
	4	468	500	532	563	582	316	348
	5	700	769	838	907	944	444	513
	6	870	980	1,090	1,200	1,255	525	672
	8	1,625	1,844	2,063	2,282	2,394	1,011	1,230
	10	2,450	2,800	3,150	3,500	3,675	1,517	1,867
	12	3,712	4,275	4,838	5,400	5,682	2,287	2,850
	14	5,251	6,188	7,125	8,063	—	3,189	4,126
	16	6,375	8,000	9,625	11,250	—	3,709	5,334
	18	7,315	9,815	12,315	14,815	—	4,084	6,584
	20	9,625	12,875	16,125	19,375	—	5,334	8,584

Series 20/21 and 30/31/3A Torques Metric (Nm)

	Valve Size mm	Valve Differential Pressure (bar)						
		Full Disc					Reduced Disc	
		0 bar	3.4 bar	7 bar	10.3 bar	12 bar	0 bar	3.4 bar
Class A Non-Corrosive, Lubricating Service	25	6	7	7	8	8	6	7
	40	9	10	10	11	11	9	10
	50	12	13	13	14	14	12	13
	65	19	20	21	22	23	19	20
	80	25	27	28	30	31	25	27
	100	39	41	44	46	48	25	28
	125	58	63	69	75	78	37	42
	150	71	80	89	99	103	39	55
	200	134	152	169	188	197	83	101
	250	199	228	257	285	300	136	153
	300	305	351	398	444	467	188	234
	350	431	508	585	663	—	262	339
	400	524	657	791	924	—	305	438
	450	595	798	1,002	1,205	—	336	541
	500	791	1,058	1,325	1,592	—	379	705
Class B General Service	25	7	7	8	9	9	7	7
	40	10	11	11	12	12	10	11
	50	14	14	15	15	16	14	14
	65	21	22	23	24	25	21	22
	80	28	29	31	33	34	28	29
	100	42	45	48	51	52	28	30
	125	63	69	76	82	85	40	46
	150	79	88	98	108	113	48	61
	200	147	167	186	206	216	91	111
	250	221	253	285	316	332	137	169
	300	336	386	437	488	514	207	258
	350	475	559	644	729	—	288	373
	400	576	723	870	1,017	—	335	482
	450	661	887	1,113	1,339	—	369	595
	500	870	1,164	1,458	1,751	—	482	776
Class C Severe Service	25	8	9	10	11	11	8	9
	40	13	13	14	15	15	13	13
	50	17	18	18	19	20	17	18
	65	26	28	29	30	31	26	28
	80	35	37	39	41	42	35	37
	100	53	56	60	64	66	36	39
	125	79	87	95	102	107	50	58
	150	98	111	123	136	142	59	76
	200	184	208	233	258	270	114	139
	250	277	316	356	395	415	171	211
	300	419	483	547	610	642	258	322
	350	593	699	805	911	—	360	466
	400	720	904	1,087	1,271	—	419	603
	450	826	1,109	1,391	1,674	—	461	744
	500	1,087	1,455	1,822	2,189	—	603	970

Series 32/33, 35/36 Torques Imperial (Lb-Ins)[1]

	Valve Size inches	32, 35 - Max △P = 75 psi				33, 36 - Max △P = 150 psi			
		0 psi	25 psi	50 psi	75 psi	0 psi	50 psi	100 psi	150 psi
Class B General Service (Imperial)	22	5,450	6,350	7,250	8,150	8,100	11,700	14,700	17,700
	24	6,700	8,100	9,500	10,900	10,500	15,000	19,500	24,000
	26	7,900	9,800	11,700	13,600	12,400	18,400	24,400	30,400
	28	9,200	11,600	14,000	16,400	14,200	21,700	29,200	36,700
	30	10,400	13,300	16,200	19,100	16,100	25,100	34,100	43,100
	32	11,700	15,600	19,400	23,300	18,400	29,700	41,100	52,400
	34	13,500	18,500	23,500	28,500	20,950	34,750	48,600	62,400
	36	14,300	20,100	25,900	31,700	23,000	39,000	55,000	71,000
	40	18,200	26,200	34,100	42,000	24,300	46,300	68,300	90,300
	42	20,200	29,200	38,200	47,200	25,000	50,000	75,000	100,000
	44	20,800	32,500	44,200	55,800	26,700	56,700	86,700	118,300
	48	22,000	39,000	56,000	73,000	30,000	70,000	110,000	150,000
Class C	54	41,500	73,500	105,500	138,000	56,300	131,000	173,000	282,000
	60	55,500	98,200	141,000	184,800	75,100	174,500	208,000	376,000
	66	115,700	159,400	203,200	247,000	161,500	277,500	393,400	509,400
	72	Consult Factory							
	78	Consult Factory							
	84	Consult Factory							
	90	Consult Factory							
	96	Consult Factory							

Series 32/33, 35/36 Torques Metric (Nm)[1]

	Valve Size mm	32, 35, - Max △P = 5 bar				33, 36 - Max △P = 10.3 bar			
		0 bar	1.7 bar	3.4 bar	5.2 bar	0 bar	3.4 bar	7 bar	10.3 bar
Class B General Service (Metric)	550	616	718	819	921	915	1,322	1,661	2,000
	600	757	915	1,074	1,232	1,187	1,695	2,204	2,712
	650	893	1,107	1,322	1,537	1,401	2,079	2,757	3,435
	700	1,040	1,311	1,582	1,853	1,605	2,452	3,300	4,147
	750	1,175	1,503	1,831	2,158	1,819	2,836	3,853	4,870
	800	1,322	1,763	2,192	2,633	2,079	3,356	4,644	5,921
	850	1,526	2,091	2,656	3,221	2,367	3,927	5,492	7,051
	900	1,616	2,271	2,927	3,582	2,599	4,407	6,215	8,023
	1,000	2,057	2,961	3,853	4,746	2,746	5,232	7,718	10,204
	1,050	2,283	3,300	4,317	5,334	2,825	5,650	8,475	11,300
	1,100	2,350	3,673	4,995	6,305	3,017	6,407	9,797	13,368
	1,200	2,486	4,407	6,328	8,249	3,390	7,910	12,430	16,950
Class C	1,400	4,689	8,304	11,920	15,592	6,361	14,801	19,546	31,862
	1,500	6,271	11,095	15,931	20,880	8,485	19,716	23,501	42,482
	1,650	13,072	18,010	22,959	27,907	18,247	31,353	44,448	57,555
	1,800	Consult Factory							
	2,000	Consult Factory							
	2,200	Consult Factory							
	2,250	Consult Factory							
	2,400	Consult Factory							

[1]Dynamic Torque values are not considered. See the Dynamic Torque chart in this manual for determination of Dynamic Torque.