RESILIENT SEATED BUTTERFLY VALVES

Technical Manual

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THE HIGH PERFORMANCE COMPANY

Resilient Seated Butterfly Valves

Technical Manual Table of Contents

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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 I – Non-Corrosive, Lubricating Service

Class II – General Service

Class III – 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.

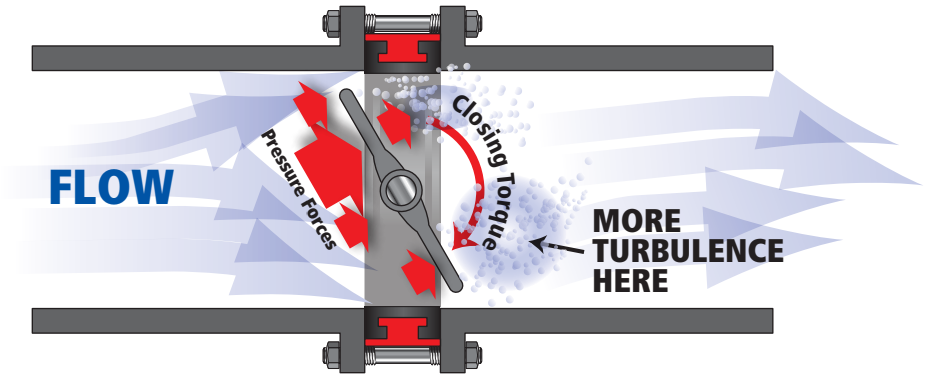
To determine dynamic torque, the following equation is applied:

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

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

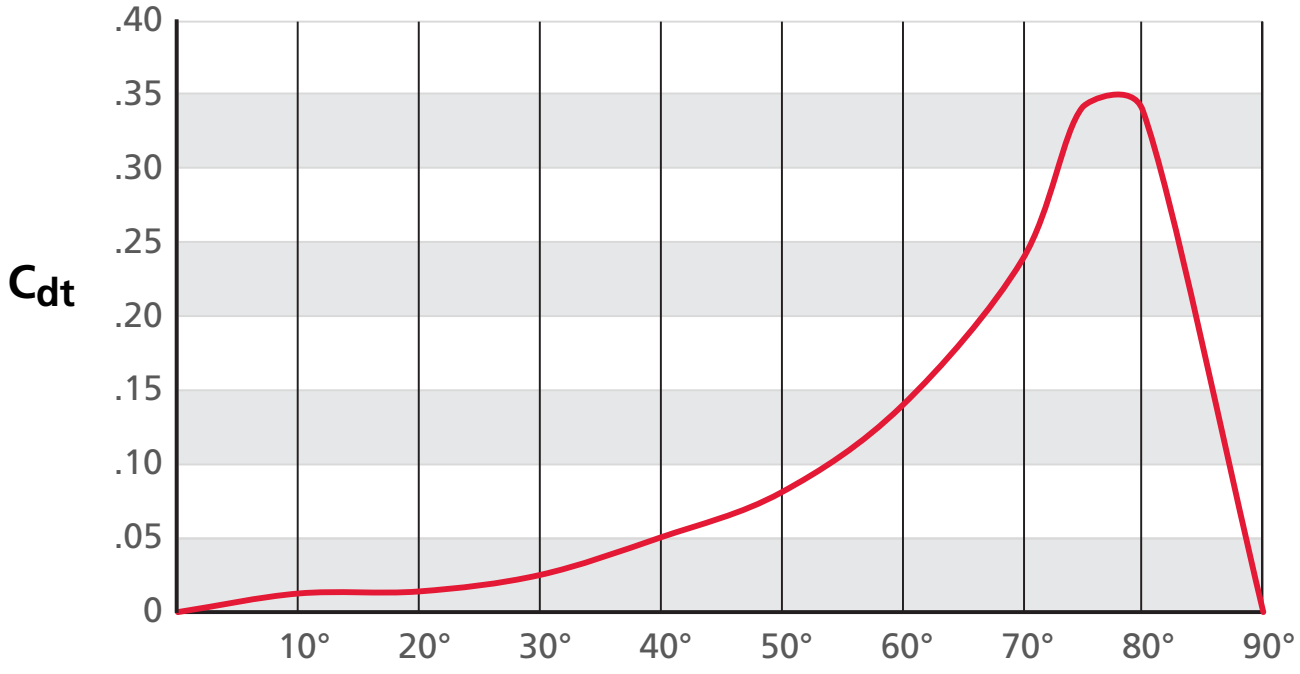
In most applications for butterfly valves, especially 20˝ (DN 500) or smaller, the maximum torque required to operate the valve will be seating/unseating torque. However, dynamic torque should be considered particularly in:

- 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)

	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)	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)

	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)	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							

Series 22/23 Torques Imperial (Lb-In) and Metric (Nm)

	In.	mm	ΔP = 0-150 psi	ΔP = 0-10.3 bar
			Lb-In	Nm
Valve Size	2	50	288	33
	2.5	65	350	40
	3	80	560	63
	4	100	720	81
	5	125	960	108
	6	150	1,300	147
	8	200	2,402	271
	10	250	3,840	434
	12	300	5,812	657
	14	350	8,000	904
	16	400	11,000	1,243
	18	450	15,500	1,751
	20	500	19,300	2,181
	24	600	30,500	3,446

1) Torques listed are for PTFE, PFA and UHMWPE trims.
2) All information based on full rated pressure differential.

DYNAMIC TORQUE FACTORS (IMPERIAL)

To Use the Torque Chart, note the following:

1. Dynamic Torque values include all bearing friction and stem-seal friction torques.
2. Dynamic Torque values are per 1 PSI ΔP. To determine dynamic torque (lb-in) at a desired angle of opening, multiply the pressure drop ΔP at this angle by the appropriate dynamic torque factor in the charts below.
3. Bray recommends sizing control valves between 20° and 70°, with 60° the preferred angle.
4. Dynamic Torque will tend to close all Bray valves whose disc are symmetrical to the stem.

Series 20/21 and 30/31/3A (Dynamic Torque Factor - lb-in./psi)

Valve Size in.	Angle of Opening									
	10°	20°	30°	40°	50°	60°	70°	75°	80°	90°
2″	0.11	0.13	0.23	0.45	0.73	1.25	2.14	3.07	3.05	0.00
2.5″	0.22	0.24	0.43	0.87	1.39	2.39	4.09	5.86	5.83	0.00
3″	0.37	0.41	0.73	1.47	2.36	4.07	6.95	9.97	9.92	0.00
4″	0.86	0.95	1.70	3.43	5.49	9.45	16.17	23.19	23.07	0.00
5″	1.65	1.83	3.29	6.61	10.59	18.25	31.22	44.77	44.53	0.00
6″	2.49	2.77	4.97	10.00	16.01	27.59	47.19	67.68	67.32	0.00
8″	6.60	6.74	12.08	24.30	38.93	67.07	114.71	164.51	163.64	0.00
10″	11.99	13.32	23.89	48.06	76.99	132.65	226.86	325.35	323.64	0.00
12″	20.89	23.21	41.62	83.74	134.14	231.14	395.30	566.91	563.93	0.00
14″	30.04	33.38	59.84	120.40	192.87	332.34	568.37	815.12	810.83	0.00
16″	45.65	50.72	90.94	182.97	293.12	505.07	863.76	1238.76	1232.24	0.00
18″	65.91	73.23	131.30	264.16	423.18	729.18	1247.04	1788.44	1779.02	0.00
20″	91.42	101.57	182.11	366.39	586.95	1011.37	1729.64	2480.55	2467.50	0.00

Example: 4″ Valve; 60° Open with a 10 PSI pressure drop: [Td = (9.454)(10) = 94.54 lb-in]

Series 32/33, 35/36 (Dynamic Torque Factor - lb-in./psi)

Valve Size in.	Angle of Opening									
	10°	20°	30°	40°	50°	60°	70°	75°	80°	90°
24″	158.36	175.95	315.46	634.69	1016.76	1751.99	2996.23	4297.03	4274.40	0.00
30″	315.32	350.35	628.13	1263.77	2024.54	3488.51	5966.01	8556.12	8511.07	0.00
36″	551.88	613.21	1099.39	2211.92	3543.45	6105.77	10442.00	14975.33	14896.49	0.00
Larger Size Valves - Consult Factory										

Example: 24″ Valve; 60° Open with a 10 PSI pressure drop: [Td = (1,751.990)(10) = 17,519.90 lb-in]

DYNAMIC TORQUE FACTORS (METRIC)

To Use the Torque Chart, note the following:

1. Dynamic Torque values include all bearing friction and stem-seal friction torques.
2. Dynamic Torque values are per 1 bar ΔP. To determine dynamic torque (Nm) at a desired angle of opening, multiply the pressure drop ΔP at this angle by the appropriate dynamic torque factor in the charts below.
3. Bray recommends sizing control valves between 20° and 70°, with 60° the preferred angle.
4. Dynamic Torque will tend to close all Bray valves whose disc are symmetrical to the stem.

Series 20/21 and 30/31/3A (Dynamic Torque Factor - Nm/bar)

Valve Size mm.	Angle of Opening									
	10°	20°	30°	40°	50°	60°	70°	75°	80°	90°
50	0.19	0.21	0.37	0.74	1.19	2.05	3.51	5.03	5.00	0.00
65	0.35	0.39	0.70	1.42	2.27	3.91	6.69	9.60	9.55	0.00
80	0.60	0.67	1.20	2.41	3.87	6.66	11.39	16.34	16.25	0.00
100	1.40	1.56	2.79	5.61	8.99	15.49	26.49	38.00	37.80	0.00
125	2.70	3.00	5.39	10.84	17.36	29.91	51.16	73.36	72.98	0.00
150	4.09	4.54	8.14	16.38	26.24	45.22	77.33	110.91	110.32	0.00
200	10.82	11.04	19.79	39.82	63.79	109.91	187.97	269.58	268.16	0.00
250	19.65	21.83	39.14	78.75	126.16	217.38	371.76	533.16	530.35	0.00
300	34.24	38.04	68.20	137.22	219.82	378.77	647.77	929.00	924.11	0.00
350	49.23	54.70	98.06	197.29	316.06	544.61	931.38	1335.74	1328.71	0.00
400	74.81	83.12	149.03	299.83	480.33	827.66	1415.46	2029.97	2019.28	0.00
450	108.01	120.01	215.15	432.88	693.46	1194.92	2043.53	2930.72	2915.29	0.00
500	149.80	166.45	298.42	600.40	961.83	1657.34	2834.37	4064.89	4043.50	0.00

Example: 100 mm Valve; 60° Open with a 10 bar pressure drop: [Td = (15.49)(2) = 30.98 Nm]

Series 32/33, 35/36 (Dynamic Torque Factor - Nm/bar)

Valve Size mm	Angle of Opening									
	10°	20°	30°	40°	50°	60°	70°	75°	80°	90°
600	259.50	288.34	516.94	1040.07	1666.17	2871.00	4909.94	7041.56	7004.49	0.00
750	516.71	574.13	1029.33	2070.95	3317.62	5716.65	9776.53	14020.96	13947.15	0.00
900	904.38	1004.86	1801.57	3624.68	5806.67	10005.56	17111.37	24540.17	24410.97	0.00
Larger Size Valves - Consult Factory										

Example: 600 mm Valve; 60° Open with a 10 bar pressure drop: [Td = (2871)(2) = 5742.00 Nm]

VALVE SIZING COEFFICIENTS

Series 20/21 - Valve Sizing Coefficient (Cv)

Valve Size inches	Disc Position (Degrees)								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
1	0.1	1	3	6	11	21	36	56	61
1.5	0.2	2	6	11	26	50	87	129	147
2	0.9	7	16	27	45	73	123	172	244
2.5	1	11	25	43	71	115	201	310	439
3	2	16	35	62	102	165	290	488	691
4	4	28	63	110	182	294	515	906	1,282
5	6	44	98	172	284	459	805	1,416	2,070
6	7	59	130	227	376	607	1,065	1,873	2,786
8	13	106	244	427	714	1,147	1,935	3,402	5,191
10	21	168	387	675	1,130	1,815	3,062	5,385	8,238
12	31	245	562	981	1,642	2,636	4,448	7,820	12,102
14	40	307	706	1,234	2,064	3,313	5,590	9,829	15,210
16	52	403	925	1,617	2,706	4,343	7,328	12,885	19,940
18	68	528	1,213	2,121	3,549	5,695	9,610	16,898	26,150
20	85	660	1,517	2,651	4,436	7,120	12,014	21,124	32,690

Series 22/23 - Valve Sizing Coefficient (Cv)

Valve Size inches	Disc Position (Degrees)								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
2	1	7	16	27	44	62	85	115	146
2.5	1	11	24	43	69	110	176	235	300
3	2	15	35	61	98	158	286	413	586
4	3	27	62	109	177	285	503	812	1,051
5	5	43	98	171	276	440	798	1,297	1,814
6	6	57	129	226	364	580	1,048	1,737	2,576
8	12	104	242	424	698	1,111	1,908	3,142	4,354
10	20	165	385	672	1,105	1,761	3,004	4,976	6,834
12	29	241	559	975	1,604	2,591	4,420	7,392	10,090
14	35	300	720	1,280	2,100	3,300	5,700	9,350	12,880
16	45	350	850	1,650	2,750	4,400	7,500	12,320	16,900
18	55	510	1,200	2,100	3,600	5,700	9,830	15,600	21,600
20	80	650	1,550	2,700	4,480	7,100	12,200	19,900	27,500
24	180	1,000	2,450	4,600	7,000	11,300	18,900	28,500	34,800

Series 30/31/31H/3A/3AH/31U - Valve Sizing Coefficient (Cv)

Valve Size Inches	Disc Position (Degrees)								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
2	0.8	7	16	27	43	61	84	114	144
2.5	1	11	24	43	67	107	163	223	282
3	2	15	35	61	96	154	267	364	461
4	3	27	62	109	171	274	496	701	841
5	5	43	98	170	268	428	775	1,146	1,376
6	6	56	129	225	354	567	1,025	1,542	1,850
8	12	102	241	421	680	1,081	1,862	2,842	3,316
10	19	162	382	667	1,076	1,710	2,948	4,525	5,430
12	27	235	555	1,005	1,594	2,563	4,393	6,731	8,077
14	34	299	756	1,320	2,149	3,384	5,939	8,874	10,538
16	45	397	1,001	1,749	2,847	4,483	7,867	11,761	13,966
18	58	507	1,281	2,237	3,643	5,736	10,065	14,496	17,214
20	72	632	1,595	2,786	4,536	7,144	12,535	18,812	22,339

Series 32/33/35/36/35F/36H - Valve Sizing Coefficient (Cv)

Valve Size Inches	Disc Position (Degrees)								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
22	103	916	2,070	3,510	5,640	9,036	14,562	22,028	27,168
24	259	1,028	2,387	4,244	6,962	11,040	18,235	27,186	33,154
26	289	1,141	2,752	4,890	7,824	12,496	19,921	29,700	36,220
28	295	1,324	3,133	5,399	8,636	13,838	22,578	34,683	41,619
30	420	1,652	3,986	7,080	11,328	18,090	28,844	43,003	52,443
32	550	2,026	4,636	7,983	12,743	20,410	32,591	48,558	60,658
34	533	2,304	5,210	8,834	14,179	22,741	36,648	55,438	68,374
36	740	2,775	5,936	9,790	15,572	25,053	40,086	59,667	77,089
40	757	2,971	6,925	11,862	19,307	30,636	50,406	73,990	90,175
42	783	3,502	7,879	12,997	21,010	35,016	54,584	83,421	102,989
44	904	4,066	8,698	14,346	22,818	36,712	58,740	87,430	112,960
48	1,023	4,651	10,365	17,010	27,242	43,853	70,431	108,968	132,888
52	Consult Factory								
54	1,299	5,904	13,158	21,594	34,583	55,671	89,411	138,334	168,700
60	1,480	6,400	14,500	24,500	39,400	63,200	102,000	154,000	190,000
66	1,650	7,110	16,100	27,300	43,800	70,200	113,000	171,000	211,000
72	1,900	8,220	18,600	31,500	50,700	81,200	131,000	198,000	244,000
78	2,290	9,910	22,400	38,000	61,000	97,800	158,000	238,000	294,000
84	2,290	11,390	25,800	43,700	70,200	112,400	181,000	274,000	338,000
90	Consult Factory								
96	Consult Factory								

Series 20/21 - Valve Sizing Coefficient (Kv)

Valve Size mm	Disc Position (Degrees)								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
25	0.087	0.865	2.595	5.190	9.515	18.165	31.140	48.440	52.765
40	0.173	1.730	5.190	9.515	22.490	43.250	75.255	111.585	127.155
50	0.779	6.055	13.840	23.355	38.925	63.145	106.395	148.780	211.060
65	0.865	9.515	21.625	37.195	61.415	99.475	173.865	268.150	379.735
80	1.730	13.840	30.275	53.630	88.230	142.725	250.850	422.120	597.715
100	3.460	24.220	54.495	95.150	157.430	254.310	445.475	783.690	1,108.930
125	5.190	38.060	84.770	148.780	245.660	397.035	696.325	1,224.840	1,790.550
150	6.055	51.035	112.450	196.355	325.240	525.055	921.225	1,620.145	2,409.890
200	11.245	91.690	211.060	369.355	617.610	992.155	1,673.775	2,942.730	4,490.215
250	18.165	145.320	334.755	583.875	977.450	1,569.975	2,648.630	4,658.025	7,125.870
300	26.815	211.925	486.130	848.565	1,420.330	2,280.140	3,847.520	6,764.300	10,468.230
350	34.600	265.555	610.690	1,067.410	1,785.360	2,865.745	4,835.350	8,502.085	13,156.650
400	44.980	348.595	800.125	1,398.705	2,340.690	3,756.695	6,338.720	11,145.525	17,248.100
450	58.820	456.720	1,049.245	1,834.665	3,069.885	4,926.175	8,312.650	14,616.770	22,619.750
500	73.525	570.900	1,312.205	2,293.115	3,837.140	6,158.800	10,392.110	18,272.260	28,276.850

Series 22/23 - Valve Sizing Coefficient (Kv)

Valve Size mm	Disc Position (Degrees)								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
50	0.865	6.055	13.840	23.355	38.060	53.630	73.525	99.475	126.290
65	0.865	9.515	20.760	37.195	59.685	95.150	152.240	203.275	259.500
80	1.730	12.975	30.275	52.765	84.770	136.670	247.390	357.245	506.890
100	2.595	23.355	53.630	94.285	153.105	246.525	435.095	702.380	909.115
125	4.325	37.195	84.770	147.915	238.740	380.600	690.270	1,121.905	1,569.110
150	5.190	49.305	111.585	195.490	314.860	501.700	906.520	1,502.505	2,228.240
200	10.380	89.960	209.330	366.760	603.770	961.015	1,650.420	2,717.830	3,766.210
250	17.300	142.725	333.025	581.280	955.825	1,523.265	2,598.460	4,304.240	5,911.410
300	25.085	208.465	483.535	843.375	1,387.460	2,241.215	3,823.300	6,394.080	8,727.850
350	30.275	259.500	622.800	1,107.200	1,816.500	2,854.500	4,930.500	8,087.750	11,141.200
400	38.925	302.750	735.250	1,427.250	2,378.750	3,806.000	6,487.500	10,656.800	14,618.500
450	47.575	441.150	1,038.000	1,816.500	3,114.000	4,930.500	8,502.950	13,494.000	18,684.000
500	69.200	562.250	1,340.750	2,335.500	3,875.200	6,141.500	10,553.000	17,213.500	23,787.500
600	155.700	865.000	2,119.250	3,979.000	6,055.000	9,774.500	16,348.500	24,652.500	30,102.000

Series 30/31/31H/3A/3AH/31U - Valve Sizing Coefficient (Kv)

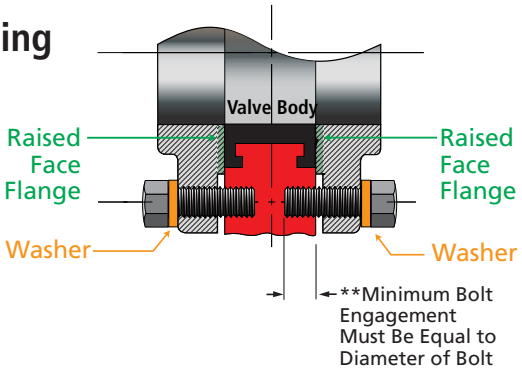
Valve Size mm	Disc Position (Degrees)								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
50	0.692	6.055	13.840	23.355	37.195	52.765	72.660	98.610	124.560
65	0.865	9.515	20.760	37.195	57.955	92.555	140.995	192.895	243.930
80	1.730	12.975	30.275	52.765	83.040	133.210	230.955	314.860	398.765
100	2.595	23.355	53.630	94.285	147.915	237.010	429.040	606.365	727.465
125	4.325	37.195	84.770	147.050	231.820	370.220	670.375	991.290	1,190.240
150	5.190	48.440	111.585	194.625	306.210	490.455	886.625	1,333.830	1,600.250
200	10.380	88.230	208.465	364.165	588.200	935.065	1,610.630	2,458.330	2,868.340
250	16.435	140.130	330.430	576.955	930.740	1,479.150	2,550.020	3,914.125	4,696.950
300	23.355	203.275	480.075	869.325	1,378.810	2,216.995	3,799.945	5,822.315	6,986.605
350	29.410	258.635	653.940	1,141.800	1,858.885	2,927.160	5,137.235	7,676.010	9,115.370
400	38.925	343.405	865.865	1,512.885	2,462.655	3,877.795	6,804.955	10,173.265	12,080.590
450	50.170	438.555	1,108.065	1,935.005	3,151.195	4,961.640	8,706.225	12,539.040	14,890.110
500	62.280	546.680	1,379.675	2,409.890	3,923.640	6,179.560	10,842.775	16,272.380	19,323.235

Series 32/33/35/36/35F/36H - Valve Sizing Coefficient (Kv)

Valve Size mm	Disc Position (Degrees)								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
550	89.095	792.340	1,790.550	3,036.150	4,878.600	7,816.140	12,596.130	19,054.220	23,500.320
600	224.035	889.220	2,064.755	3,671.060	6,022.130	9,549.600	15,773.275	23,515.890	28,678.210
650	249.985	986.965	2,380.480	4,229.850	6,767.760	10,809.040	17,231.665	25,690.500	31,330.300
700	255.175	1,145.260	2,710.045	4,670.135	7,470.140	11,969.870	19,529.970	30,000.795	36,000.435
750	363.300	1,428.980	3,447.890	6,124.200	9,798.720	15,647.850	24,950.060	37,197.595	45,363.195
800	475.750	1,752.490	4,010.140	6,905.295	11,022.695	17,654.650	28,191.215	42,002.670	52,469.170
850	461.045	1,992.960	4,506.650	7,641.410	12,264.835	19,670.965	31,700.520	47,953.870	59,143.510
900	640.100	2,400.375	5,134.640	8,468.350	13,469.780	21,670.845	34,674.390	51,611.955	66,681.985
1,000	654.805	2,569.915	5,990.125	10,260.630	16,700.555	26,500.140	43,601.190	64,001.350	78,001.375
1,050	677.295	3,029.230	6,815.335	11,242.405	18,173.650	30,288.840	47,215.160	72,159.165	89,085.485
1,100	781.960	3,517.090	7,523.770	12,409.290	19,737.570	31,755.880	50,810.100	75,626.950	97,710.400
1,200	884.895	4,023.115	8,965.725	14,713.650	23,564.330	37,932.845	60,922.815	94,257.320	114,948.120
1,300	Consult Factory								
1,400	1,123.635	5,106.960	11,381.670	18,678.810	29,914.295	48,155.415	77,340.515	119,658.910	145,925.500
1,500	1,280.200	5,536.000	12,542.500	21,192.500	34,081.000	54,668.000	88,230.000	133,210.000	164,350.000
1,650	1,427.250	6,150.150	13,926.500	23,614.500	37,887.000	60,723.000	97,745.000	147,915.000	182,515.000
1,800	1,643.500	7,110.300	16,089.000	27,247.500	43,855.500	70,238.000	113,315.000	171,270.000	211,060.000
2,000	1,980.850	8,572.150	19,376.000	32,870.000	52,765.000	84,597.000	136,670.000	205,870.000	254,310.000
2,200	1,980.850	9,852.350	22,317.000	37,800.500	60,723.000	97,226.000	156,565.000	237,010.000	292,370.000
2,250	Consult Factory								
2,400	Consult Factory								

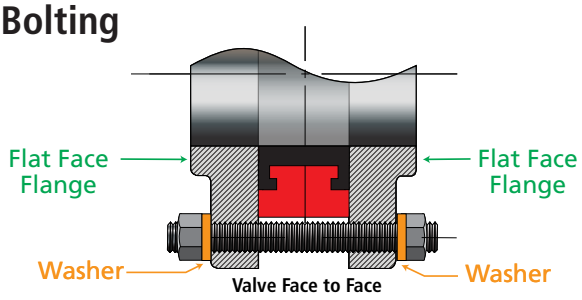
EXAMPLES OF TYPICAL FLANGE TO VALVE BOLTING*

** Lug Style Bolting

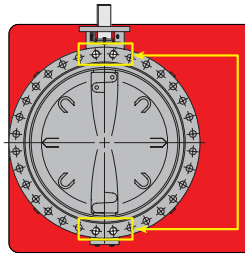


Flange Width Including Raise Face If Applicable + Washer Width + Minimum Bolt Engagement Equal to Bolt Diameter = Bolt Length

** Wafer Style Bolting



Flange Width x2 Including Raise Face If Applicable + Valve Face to Face + Washer Width x2 + Width of Nut x2 + 4 Threads (2 Per Side) = Overall Length



**** Note: Please refer to Appropriate Bray Dimensional Drawings for specific valve drilling information on Wafer and Lug Valves 20" and larger.**

Please refer to ASME B-16.5 or B-16.47 for Flange and Bolt Dimension Information

* Double flange style bolting not shown.
** Lug threads may be tapped from both sides and therefore tap may not be continuous.

FLANGE BOLT TENSIONING
Bray Butterfly Valves with Metal Mating Flanges

A question frequently asked at Bray is "What torque do I apply to the flange bolts to insure the valve is properly installed?". Initially this seems to be a simple request until all of the factors are analyzed. The installation of a valve requires several components: the valve, mating flanges, nuts, bolts and studs. Each is supplied by different manufacturers and each has different characteristics. The proper torque for one combination may be too much or too little for a second combination. The following is a list of information which needs to be known in order to start calculating the torque requirements.

Valve
- Type
- Size
- Materials of construction (Body)
- Surface finishes / Surface conditions

Flange
- Type
- Size
- Finish / both sides
- Condition of flange / surface contamination

Bolt (or Stud)
- Type
- Materials of Construction
- Surface Conditions

Nut
- Type
- Materials of Construction
- Surface Conditions

Lubrication
- Type
- Coverage

General Factors
- Temperature and relative humidity at the time of installation
- Speed at which bolts are turned

Note: The elastomer valve seat manufactured by Bray also acts as the flange gasket. No additional gaskets are required or recommended. Other valve styles which do not have integral gaskets will need to have this component supplied. The characteristics of this component will also need to be considered.

Complete knowledge of all relevant conditions is almost impossible to obtain. As a result, the computation of the exact torque requirement is not practical. No reputable manufacturer can provide accurate information when so many outside factors are present.

The International Fasteners Institute covers some of the details required to "compute" a torque value. Even with this information the use of a torque wrench is only considered to be 25% accurate. Based on the difficulty and inaccuracy of using this method, Bray recommends the use of the "Turn of the nut" method.

"Turn of the Nut" Tightening
(For ANSI Standard Iron and Steel Flanges)
**For Non-Metallic or non-standard flanges, follow the manufacturers installation procedures.

1. The valve and flange faces must be aligned parallel to each other.

   Note: For rubber seated butterfly valves manufactured by Bray, it is required that the valve be fully opened prior to the tightening of the flange bolts.

2. After aligning the holes in a joint, sufficient bolts shall be placed and brought to a 'snug-tight' condition to ensure that the parts of the joint are *brought into full contact* with each other. 'Snug-Tight' is the tightness attained by the full effort of a man using a spud wrench.

3. Following the initial snugging operation, bolts shall be placed in any remaining holes and brought to snug-tightness. Re-snugging may be necessary in large joints.

4. Tighten opposite bolts in sequence to insure even pressure around the entire flange.

5. When all bolts are snug-tight, each bolt in the joint then shall be tightened additionally by the applicable amount of nut rotation given in Note 1. During tightening there shall be no rotation of the valve or flange.

Note 1

For bolt lengths **not exceeding** 8 diameters or 8 inches (203.2 mm) = **1/4 turn**
For bolt lengths **exceeding** 8 diameters or 8 inches (203.2 mm) = **1/2 turn**

Disclaimer:
Bray Controls is issuing these recommendations only as a guide to installation. This recommendation is based on the full compliance of all materials supplied to their appropriate specifications. Since many of the components are not manufactured by Bray we can take no responsibility for any damage caused during installation.

Series 20/21 and 30/31 - Flange Bolt Torque Chart

Valve Size		Normal Torque Range	Normal Torque Range
In	mm	Ft-lbs	Nm
2	50	30	40
2.5	65	30	40
3	80	35	50
4	100	35 - 40	50 - 55
5	125	35 - 45	50 - 60
6	150	35 - 50	50 - 65
8	200	45 - 55	60 - 75
10	250	55 - 75	75 - 100
12	300	65 - 110	90 - 150
14	350	75 - 120	100 - 165
16	400	75 - 120	100 - 165
18	450	85 - 130	115 - 175
20	500	85 - 130	115 - 175

Please note that the Nm and Ft-lbs values are based on bolt size in respective metric and ANSI flanges, i.e. these values are not a direct conversion between Nm and Ft-lbs.

The values represent average torques needed to ensure full compression of the resilient valves' seats into the valves' bodies when installed in pipeline flanges. The face of both flanges must come into full contact with the valves' metal bodies.

No additional torque is required for proper functioning of the Bray resilient seated valves.

The torque values are based on using new, coarse-threaded, lubricated fasteners. Up to 25% may be added to the Normal Torque Range values when using non-lubricated fasteners.

Torque Values specified by flange manufacturers ***must not be exceeded.***

Series 22/23 Installation - Flange Bolt Torque Chart, 150 lb Flanges

Valve Size		Normal Torque Range		Max Torque Range	
In	mm	Ft-lbs	Nm	Ft-lbs	Nm
2	50	30	40	35	50
2.5	65	30	40	35	50
3	80	35	50	40	55
4	100	35 - 40	50 - 55	40	55
5	125	35 - 45	50 - 60	50	65
6	150	35 - 50	50 - 65	65	90
8	200	45 - 55	60 - 75	80	110
10	250	55 - 75	75 - 100	100	135
12	300	65 - 110	90 - 150	120	165
14	350	75 - 120	100 - 165	140	190
16	400	75 - 120	100 - 165	140	190
18	450	85 - 130	115 - 175	170	230
20	500	85 - 130	115 - 175	180	245
24	600	100 - 150	135 - 205	220	300

The torque values are based on using new, coarse-threaded, lubricated fasteners. Up to 15% may be added to the Normal Torque Range values when using non-lubricated fasteners. However, the maximum torque should not be exceeded.

Flange gaskets are normally not used for installation of S22/23 valves. Flange leakage may be caused by combination of out-of-parallel and/or misaligned flanges, and surface damage on the flange face and/or the face of the valve seat. In such cases, suitable flange gaskets may be used to control flange leakage.

Torque values specified by manufacturers of certain flanges, for example plastic flanges, could be lower than the values specified above. In such cases, the flange manufacturers' torque values must not be exceeded. Use flange gaskets if necessary to secure flange seal.

Series 20/21 - Standard Metal Specifications

Part		Material	ASTM No.	UNS No.
Body		Cast Iron	A126 Class B	
		Ductile Iron	A395 Gr. 60-40-18	F32800
		316 Stainless Steel	A351 CF8M	J92900
		Aluminum	B26 Class B	
Disc/Stem 1-12"(25-300mm) One Piece		316 Stainless Steel	A351 CF8M	J92900
		Hastelloy® C22 *	B494 CX2MW	N26022
		17-4 ph Stainless Steel	A747 CB7Cu1 Heat Treated	J92180
Disc/Stem 14-20" (350-500mm) Fabricated	**Disc**	316 Stainless Steel	A240	S31600
		Hastelloy® C276 *	B575	N10276
		17-4 ph Stainless Steel	A564 630 Heat Treated	S17400
	Stem	316 Stainless Steel	A276	S31600
		Hastelloy® C276 *	B575	N10276
		17-4 ph Stainless Steel	A564 630 Heat Treated	S17400

Series 22/23 - Standard Metal Specifications

Part	Material	ASTM No.	UNS No.
Body	Ductile Iron	A395 Gr. 60-40-18	F32800
	316 Stainless Steel	A351 CF8M	J92900
	Carbon Steel	A216 WCB	J030002
Disc	316 Stainless Steel	A351 CF8M	J92900
	PTFE/316 SS (2"-12")	A351 CF8M	J92900
	PTFE/17-4 ph SS (14"-24")	A547 CB7Cu1	J92180
	PFA/316 SS (2"-12")	A351 CF8M	J92900
	PFA/17-4 ph SS (14"-24")	A547 CB7Cu1	J92180
	UHMWPE/316 SS (2"-6")	A351 CF8M	J92900
	UHMWPE/DI (8"-12")	A536 Gr 65-45-12	F33100
	Hastelloy® C22 *	B494 CX2MW	N26022
	Titanium		
Stem	17-4 ph Stainless Steel	A564 630 Heat Treated	S17400

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Series 30/31, 31H, 3A/3AH, 31U - Standard Metal Specifications

Part	Material	ASTM No.	UNS No.	30/31	31H	3A/3AH	31U
Body	Cast Iron	A126 Class B		●	●	●	
	Ductile Iron	A536 Gr. 65-45-12	F33100	●	●	●	
	Ductile Iron	A395	F32800				●
	Carbon Steel	A216 WCB	J030002	●		●	●
	Nickel Aluminum Bronze	B148	C95800				●
	Aluminum	B26 Class B		●			
Disc	Aluminum Bronze	B148	C95400	●	●	●	
	Nickel Aluminum Bronze	B148	C95800				●
	Nylon Coated Ductile Iron	A536 Gr. 65-45-12	F33100	●	●	●	
	316 Stainless Steel	A351 CF8M	J92900	●	●	●	●
	304 Stainless Steel	A351 CF8	J92600	●		●	
	Duplex Stainless Steel	A995 Gr 4A	J92205	●		●	
	Super Duplex Stainless Steel	A995 Gr 5A	J93404	●		●	
	Super Austenitic Stainless Steel (254 SMO™)*	A351 Grade CK3MCuN	S31254	●		●	
	Hastelloy® C-276 *	B575	N10276	●		●	
Stem	304 Stainless Steel	A276	S30400	●		●	
	316 Stainless Steel	A276	S31600	●		●	
	416 Stainless Steel	A582	S41600	●	●	●	●
	17-4 ph Stainless Steel	A564 630 Heat Treated	S17400				●
	Monel® *	B865	N05500	●		●	●

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Series 32/33, 35/36, 35F, 36H - Standard Metal Specifications

Part	Material	ASTM No.	UNS No.	32-36	36H	35F
Body	Cast Iron	A126 Class B		●		●
	Ductile Iron	A536 Gr. 65-45-12	F33100	●	●	●
	Carbon Steel	A216 Gr. WCB	J030002	●		
	316 Stainless Steel	A351 CF8M	J92900	●		
Disc	Nickel Aluminum Bronze	B148	C95800	●	●	
	Nylon Coated Ductile Iron	A536 Gr. 65-45-12	F33100	●	●	
	316 Stainless Steel	A351 CF8M	J92900	●		
	304 Stainless Steel	A351 CF8	J92600	●		
	Hastelloy® C-276 *	B575	N10276	CF		●
	Hastelloy® C-22 *	B494 CX2MW	N26022	CF		
	Duplex Stainless Steel	A995 Gr 5A	J93404	●	●	●
	Super Austenitic Stainless Steel (254 SMO ™) *	A351 Grade CK3MCuN	S31254	●	●	●
	Monel® *	A494 Grade M-35-1	N24135	●		
Stem	304 Stainless Steel	A276	S30400	●		●
	316 Stainless Steel	A276	S31600	●		●
	416 Stainless Steel	A582	S41600	●		
	17-4 ph Stainless Steel	A564 630 Heat Treated	S17400	●	●	
	Austenitic Stainless Steel	A479	S31651	●		
	Super Austenitic Stainless Steel (AL-6XN®) *	A276	N08367	●	●	
	Monel® *	B865	N05500	●		

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