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For External Distribution

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1 Introduction

This technical document sets forth guidelines for assembly of tapped full lug knife gate valves to process piping flanges. Valves that fall under the purview of this document include SSKGV Class 150 through 600. Primary intent of this document is to provide minimum and allowable torque needed to induce proper bolt stress values required to achieve proper performance. This document is not to be used as the sole reference to determine proper assembly methods and procedures, bolt torquing techniques, gasket selection, and subsequent testing procedures.

2 Bolt Torque

Bolt torque is simply the torque that is applied to a bolt or screw for the purpose of inducing a bolt tensile load. Bolt load is the resultant force that is applied by a bolt that has been stretched, ultimately producing a resultant bolt pre-stress.

The predominant method of applying proper bolt pre-load is through direct measurement of bolt torque. Bolt torque is commonly applied through handheld tools whereby the accuracy and precision of torque measurement varies by type.

Many factors affect the accuracy by which the pre-determined bolt torque achieves the desired bolt pre-load. A short list of important factors affecting the relationship between bolt torque and pre-load include lubrication, condition of internal and external thread, condition of bolt head and head seating surface, and external bolt loads prior to assembly. It is the responsibility of the assembly personnel to determine the state of these factors and make all necessary adjustments.

3 Joint Assembly Best Practices and Rules of Thumb

Adhering to several standard practices during joint assembly is imperative. Presented here is a list of standard practices that should be followed to ensure a properly seated joint.

- Always use new and unused bolts, screws, studs, nuts, and washers.
- All bolts, screws, studs, nuts, and washers shall be free from debris and of damage.
- Bolts and studs shall be threaded into the valve by hand to assure that they do not bottom out within the valve tapped hole. Special attention must be given to blind flange holes in the valve chest region as bolts that bottom out in these holes with force can damage the valve and or create increased actuation thrust requirements.
- Properly aligned flanges will allow for bolts and studs to freely pass through the pipe flange and freely thread into the valve's corresponding flange thread.
- Flanges shall be parallel within 1/32 of an inch at the OD of the sealing surface. Parallelism requirement can be achieved using up to 10% of the required final bolt load for any bolt.
- Flanges shall be brought into contact with the uncompressed gasket using not more than 10% of the total required bolt load. No more than 20% of an individual final bolt load shall be applied to any single bolt during this procedure.

- External alignment tools shall apply no greater than 20% of the total required bolt load while bringing the flanges into alignment evenly with the uncompressed gasket.
- Flange to flange centerline misalignment shall not exceed 1/8 of an inch.
- Rotational misalignment of flanges shall not exceed 1/8 of an inch.

4 Minimum Bolt Pre-Stress

In any instance in which the target gasket stress is unknown, it is recommended that a minimum bolt stress of 31,500psi be induced when using A193 Grade B7 bolts or equivalent fasteners. Recommended minimum bolt stress is 30% of the yield stress of A193 Grade B7 fasteners and is regarded as the minimum bolt stress that shall be used during assembly of DSS knife gate valves. It is the responsibility of the end user to assure the minimum torques defined within this document will be acceptable for the specific requirements of their application. See section 5 if the application requires greater bolt pre-load than provided by the defined minimum torques.

Tables 1 through 4 below detail the torques that are required for each valve flange to achieve the minimum required bolt load. All bolt torques were calculated using the short form bolt preload equation and assuming a friction coefficient factor (K) of .16. It is the responsibility of the installer to determine and verify the K factor for their specific joint.

$$T = K * D * P$$

where:

$K = Coefficent\ of\ Friction\ Factor$
$D = Nominal\ Bolt\ Diameter\ [inches]$
$P = Desired\ Bolt\ Load\ [lbf]$
$T = Required\ Torque\ [ft * lbf]$

M81 Minimum Bolt Pre-Stress Flange Torques [Table 1]

NPS [inch]	Bolt	Number of Bolts	Torque [ft*lbf]	Bolt Load [lbf]
2	5/8-11	4	60	7,119
3	5/8-11	4	60	7,119
4	5/8-11	8	60	7,119
5	3/4-10	8	107	10,536
6	3/4-10	8	107	10,536
8	3/4-10	8	107	10,536
10	7/8-9	12	163	13,806
12	7/8-9	12	172	14,545

Class 150 Minimum Bolt Pre-Stress Flange Torques [Table 2]

NPS [inch]	Bolt	Number of Bolts	*Torque [ft*lbf]	Bolt Load [lbf]
2	5/8-11	4	60	7,119
3	5/8-11	4	60	7,119
4	5/8-11	8	60	7,119
5	3/4-10	8	107	10,536
6	3/4-10	8	107	10,536
8	3/4-10	8	107	10,536
10	7/8-9	12	163	13,806
12	7/8-9	12	172	14,545
14	1-8	12	246	18,173
16	1-8	16	258	19,081
18	1 1/8-8	16	378	24,899
20	1 1/8-8	20	378	24,899
22	1 1/4-8	20	530	31,491
24	1 1/4-8	20	530	31,491
26	1 1/4-8	28	530	31,491
28	1 1/4-8	28	530	31,491
30	1 1/4-8	28	530	31,491
32	1 1/2-8	28	947	46,993
36	1 1/2-8	32	947	46,993
42	1 1/2-8	36	947	46,993
48	1 1/2-8	44	947	46,993

*Torque values for 8-pitch threads can be applied to the UNC series for threads above 1-inch.

Class 300 Minimum Bolt Pre-Stress Flange Torques [Table 3]

NPS [inch]	Bolt	Number of Bolts	*Torque [ft*lbf]	Bolt Load [lbf]
2	5/8-11	8	60	7,119
3	3/4-10	8	107	10,536
4	3/4-10	8	107	10,536
6	3/4-10	12	107	10,536
8	7/8-9	12	172	14,545
10	1-8	16	258	19,081
12	1 1/8-8	16	378	24,899
14	1 1/8-8	20	378	24,899
16	1 1/4-8	20	530	31,491
18	1 1/4-8	24	530	31,491
20	1 1/4-8	24	530	31,491
24	1 1/2-8	24	947	46,933
26	1 5/8-8	28	1,218	55,904
28	1 5/8-8	28	1,218	55,904
30	1 3/4-8	28	1,537	65,588
32	1 7/8-8	28	1,907	76,045
36	2-8	32	2,332	87,275
42	1 5/8-8	32	1,218	55,904
48	1 7/8-8	32	1,907	76,045

*Torque values for 8-pitch threads can be applied to the UNC series for threads above 1-inch.

Class 600 Minimum Bolt Pre-Stress Flange Torques [Table 4]

NPS [inch]	Bolt	Number of Bolts	*Torque [ft*lbf]	Bolt Load [lbf]
2	5/8-11	8	60	7,119
3	3/4-10	8	107	10,536
4	7/8-9	8	172	14,545
6	1-8	12	258	19,081
8	1 1/8-8	12	378	24,899
10	1 1/4-8	16	530	31,491
12	1 1/4-8	20	530	31,491
14	1 3/8-8	20	719	38,855
16	1 1/2-8	20	946	46,933

*Torque values for 8-pitch threads can be applied to the UNC series for threads above 1-inch.

5 Maximum Allowable Torque to Achieve Maximum Allowable Bolt Pre-Stress

Maximum allowable bolt pre-stress is limited by either the bolt or screw of interest or the maximum allowable stress of the valve flange threads. Our focus will be on the limits imposed by the valve flange threads, and the related torque. Valve bodies of differing materials will have different allowable maximum bolt pre-load limits and must be evaluated on an individual basis. As discussed earlier, bolt pre-stress is commonly determined by direct measurement of bolt or screw torque.

Maximum allowable flange torques that can be applied to DSS valves are given in Tables 5 through 7. Tables for each valve class within the SSKGV product range are provided with the M81 series being combined within the class 150 table. Each table includes 4 common materials of construction for quick reference. Valve materials not included within the table can easily be determined with a material multiplier provided within Table 8. When determining the maximum allowable bolt torque for unlisted materials, multiply the material multiplier in Table 8 to the maximum allowable flange bolt torque for 316 stainless steel. All torques within these tables were determined based on a K factor of .16. Each application has the potential to have a different K factor which can be affected by lubricants, bolt coating, thread condition, and thread geometry. It is the responsibility of the installer to determine and verify the K factor for their specific joint.

Different applications will require specific gaskets each having their own gasket seating stress that must be achieved for proper sealing characteristics. It is imperative that the calculated bolt torque required to achieve the desired gasket stress is equal to or less than the maximum allowable flange bolt torque for the valve size and material being evaluated. If the required torque exceeds the maximum allowable a different gasket must be used that will require a lower bolt torque that is at or below the maximum allowable.

Class 150 (M81 through NPS 12) Maximum Allowable Flange Bolt Torques [Table 5]

NPS [inch]	Bolt	Number of Bolts	*316 SS Torque [ft*lbf]		*Titanium Gr. 2 Torque [ft*lbf]		*Ni-Resist Type 1 Torque [ft*lbf]		*Duplex SS 2205 Torque [ft*lbf]	
			FF	RF	FF	RF	FF	RF	FF	RF
2	5/8-11	4	86	76	114	101	143	126	185	164
3	5/8-11	4	96	86	128	115	159	143	207	186
4	5/8-11	8	96	86	128	115	159	143	207	186
5	3/4-10	8	134	119	178	159	223	199	290	258
6	3/4-10	8	134	119	178	159	223	199	290	258
8	3/4-10	8	183	168	243	224	304	280	396	364
10	7/8-9	12	183	163	245	218	306	272	398	354
12	7/8-9	12	234	214	311	285	389	356	506	463
14	1-8	12	272	246	363	328	454	410	590	533
16	1-8	16	351	325	469	433	586	542	761	704
18	1 1/8-8	16	516	483	688	644	860	805	1,118	1,046
20	1 1/8-8	20	594	561	792	747	990	934	1,287	1,215
22	1 1/4-8	20	643	602	858	803	1,072	1,004	1,394	1,305
24	1 1/4-8	20	718	677	958	903	1,197	1,129	1,557	1,468
26	1 1/4-8	28	889	848	1,186	1,131	1,482	1,414	1,927	1,838
28	1 1/4-8	28	978	937	1,305	1,250	1,631	1,562	2,120	2,031
30	1 1/4-8	28	889	848	1,186	1,131	1,482	1,414	1,927	1,838
32	1 1/2-8	28	1,276	1,218	1,702	1,623	2,127	2,029	2,766	2,638
36	1 1/2-8	32	1,159	1,100	1,545	1,466	1,931	1,833	2,510	2,383
42	1 1/2-8	36	2,200	2,141	2,933	2,854	3,666	3,568	4,766	4,638
48	1 1/2-8	44	2,013	1,954	2,684	2,605	3,355	3,257	4,361	4,234

*Torque values for 8-pitch threads can be applied to the UNC series for threads above 1-inch.

Class 300 Maximum Allowable Flange Bolt Torques [Table 6]

NPS [inch]	Bolt	Number of Bolts	*316 SS Torque [ft*lbf]		*Titanium Gr. 2 Torque [ft*lbf]		*Ni-Resist Type 1 Torque [ft*lbf]		*Duplex SS 2205 Torque [ft*lbf]	
			FF	RF	FF	RF	FF	RF	FF	RF
2	5/8-11	8	116	104	154	139	193	173	251	225
3	3/4-10	8	153	139	204	185	256	231	332	301
4	3/4-10	8	183	168	243	224	304	280	396	364
6	3/4-10	12	197	183	263	243	329	304	427	396
8	7/8-9	12	290	270	387	360	484	450	629	585
10	1 -8	16	575	549	767	732	959	915	1,247	1,190
12	1 1/8-8	16	688	655	918	873	1,147	1,092	1,491	1,419
14	1 1/8-8	20	622	588	829	784	1,036	981	1,347	1,275
16	1 1/4-8	20	1,026	985	1,368	1,314	1,711	1,642	2,224	2,135
18	1 1/4-8	24	1,102	1,061	1,469	1,414	1,836	1,768	2,387	2,298
20	1 1/4-8	24	1,191	1,149	1,587	1,533	1,984	1,916	2,580	2,491
24	1 1/2-8	24	1,954	1,895	2,605	2,527	3,257	3,159	4,234	4,106
26	1 5/8-8	28	2,370	2,301	3,160	3,068	3,950	3,835	5,134	4,985
28	1 5/8-8	28	2,370	2,301	3,160	3,068	3,950	3,835	5,134	4,985
30	1 3/4-8	28	3,076	2,996	4,102	3,995	5,127	4,994	6,665	6,492
32	1 7/8-8	28	3,907	3,815	5,209	5,087	6,511	6,359	8,465	8,266
36	2-8	32	5,307	5,203	7,076	6,938	8,845	8,672	11,499	11,273
42	1 5/8-8	32	2,956	2,887	3,942	3,850	4,927	4,812	6,406	6,256
48	1 7/8-8	32	3,052	2,961	4,070	3,947	5,087	4,934	6,613	6,415

*Torque values for 8-pitch threads can be applied to the UNC series for threads above 1-inch.

Class 600 Maximum Allowable Flange Bolt Torques [Table 7]

NPS [inch]	Bolt	Number of Bolts	*316 SS Torque [ft*lbf]		*Titanium Gr. 2 Torque [ft*lbf]		*A516 Torque [ft*lbf]		*Duplex SS 2205 Torque [ft*lbf]	
			FF	RF	FF	RF	FF	RF	FF	RF
2	5/8-11	8	138	96	184	128	173	120	298	207
3	3/4-10	8	200	139	266	185	251	174	432	301
4	7/8-9	8	350	267	467	356	440	335	759	578
6	1 -8	12	514	404	685	539	646	508	1,114	876
8	1 1/8-8	12	755	616	1,006	821	949	774	1,635	1,335
10	1 1/4-8	16	1,061	889	1,414	1,186	1,333	1,118	2,298	1,927
12	1 1/4-8	20	1,149	889	1,533	1,186	1,445	1,118	2,491	1,927
14	1 3/8-8	20	1,074	868	1,433	1,157	1,350	1,091	2,328	1,880
16	1 1/2-8	20	2,013	1,767	2,684	2,356	2,530	2,221	4,361	3,829

*Torque values for 8-pitch threads can be applied to the UNC series for threads above 1-inch.

Material Multipliers [Table 8]

17.4 PH [A747 CB7Cu-1]	316 SS [A351 CF8M]	317 SS [A351 CG8M]	AL6XN [A351 CN3MN]	Alloy 20 [A351 CN7M]	Carbon Steel [A516 & WCB]
3.52	1.00	1.17	1.27	7,119	1.26

Cast Iron [A356 65-45-12]	Duplex 2205 [A995 Gr. 4A CD3MN]	Hastelloy C-276 [A494 CW12MW]	Ni-Resist Type 1 [A436 Gr. 1]	Ductile Ni-Resist D2 [A439 D2]	Super Duplex 2507 [A995 Gr. 5A CE3MN]
1.5	2.00	1.33	1.67	1.21	2.50

Titanium Gr. 2 [B367 Gr. C-2]	Titanium Gr. 5 [B367 Gr. C-5]	Titanium Gr. 7 [B367 Gr. C-7]	Titanium Gr. 8 [B367 Gr. C-8]	Titanium Gr. 12 [B367 Gr. C-12]
1.33	4.00	1.33	1.83	1.67