

JOINT STRENGTH FORMULAS FOR API THREADED LINE PIPE

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The following formulas for the fracture strength and the pull-out or jump-out strength of API threaded line pipe joints have been adapted from the formulas given in the paper entitled "Strength of Threaded Joints for Steel Pipe" presented by the author at the A.S.M.E. Petroleum Division Conference in June 1964.

Fracture Strength

$$P_f = AU \dots\dots\dots(1)$$

Pull-out Strength

$$P_p = AL \left[ \frac{2.39(2h)^{0.59} D^{-0.59} U}{0.5L + 0.14D} + \frac{Y}{L + 0.14D} \right] \dots\dots\dots(2)$$

where:

A = cross-sectional area of pipe wall under last perfect thread, square inches

$$= 0.7854 ((D - 2h_s)^2 - (D - 2t)^2)$$

D = outside diameter, inches

t = wall thickness, inches

P<sub>f</sub> = joint fracture strength, pounds

P<sub>p</sub> = joint pull-out strength, pounds

U = ultimate strength of pipe, psi

Y = yield strength of pipe, psi

L = engaged thread length, inches

h = thread height, inches

s = 0.0950 for 8 threads per inch

= 0.0661 " 11 1/2 " " "

= 0.0543 " 14 " " "

= 0.0422 " 18 " " "

= 0.0281 " 27 " " "

h = engaged height of thread, inches

= H - (f<sub>cs</sub> + f<sub>cn</sub>) determined from API Spec. 5B

= 0.0900 for 8 threads per inch

= 0.0627 " 11 1/2 " " "

= 0.0515 " 14 " " "

= 0.0399 " 18 " " "

= 0.0267 " 27 " " "

2.39(2h)<sup>0.59</sup> = 0.87 for 8 threads per inch

= 0.70 " 11 1/2 " " "

= 0.63 " 14 " " "

= 0.54 " 18 " " "

= 0.42 " 27 " " "

Ten tensile tests of 2 inch extra strong and five tensile tests of 2 1/2 inch extra strong API line pipe joints were made by Wheeling Machine Products Company at the Pittsburgh Testing Laboratory. The test specimens were cut from three lengths of pipe; five tests from each length. Companion strip tensile tests were made on each length. The joint test data are shown in table 1.

Using the test data shown in table 1, values of pull-out and fracture strength were calculated using formulas 1 and 2, and shown in table 2 in comparison with the test failure loads. The ratio of test values to formula values is seen to average 0.983 with a standard deviation of 0.054 demonstrating good agreement with the tests. It should be noted that all tests except No. 14 failed by pull-out. Test No. 14 failed by fracture as predicted by the formula.

Formulas 1 and 2 converted to a minimum basis are as follows:

Minimum Fracture Strength

$$P_f = 0.95AU \dots\dots\dots(3)$$

Minimum Pull-out Strength

$$P_p = 0.95AL \left[ \frac{2.39(2h)^{0.59} D^{-0.59} U}{0.5L + 0.14D} + \frac{Y}{L + 0.14D} \right] \dots\dots\dots(4)$$

where:

- D = tabulated outside diameter, inches
- t = tabulated wall thickness, inches
- L = L<sub>4</sub> - M determined from API Spec. 5B, inches
- P<sub>f</sub> = minimum joint fracture strength, pounds
- P<sub>p</sub> = minimum joint pull-out strength, pounds
- U = minimum ultimate strength, psi
- Y = minimum yield strength, psi

All other factors are as shown for formulas 1 and 2

Using formulas 3 and 4, minimum joint strength values for API standard-weight threaded line pipe were calculated and shown in table 3. For sizes 1 1/4 inch and smaller fracture strength is critical while for sizes 1 1/2 inch and larger pull-out strength is critical.

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Table 1  
Joint Test Data

Test No.	Average OD	Average Wall	Engaged Thread Length	Tensile Properties		Test Failure Load	Type of Failure
	D in.	t in.	L in.	Y ksi	U ksi	1000 lbs.	
1	2.383	0.225	0.469	47.0	73.0	51.5	Pull-out
2	"	"	"	"	"	52.9	"
3	"	"	"	"	"	49.5	"
4	"	"	"	"	"	53.8	"
5	"	"	"	"	"	49.2	"
6	2.390	0.230	0.656	39.9	65.5	57.3	"
7	"	"	"	"	"	55.5	"
8	"	"	"	"	"	57.5	"
9	"	"	0.687	"	"	61.3	"
10	"	"	0.557	"	"	49.5	"
11	2.890	0.295	1.031	43.8	72.1	110.2	"
12	"	"	"	"	"	113.0	"
13	"	"	"	"	"	112.4	"
14	"	"	1.188	"	"	116.2	Fracture
15	"	"	1.031	"	"	114.5	Pull-out

Table 2  
Comparison of Formulas With Test Values

Test No.	Test Failure Load 1000 lbs.	Type of Failure	Formula Strength		Test/Formula
			Pull-out Critical 1000 lbs.	Fracture 1000 lbs.	
1	51.5	Pull-out	55.1	76.2	0.935
2	52.9	"	55.1	76.2	0.960
3	49.5	"	55.1	76.2	0.898
4	53.8	"	55.1	76.2	0.976
5	49.2	"	55.1	76.2	0.893
6	57.3	"	57.8	70.6	0.991
7	55.5	"	57.8	70.6	0.960
8	57.5	"	57.8	70.6	0.995
9	61.3	"	58.9	70.6	1.041
10	49.5	"	53.7	70.6	0.922
11	110.2	"	108.4	113.3	1.017
12	113.0	"	108.4	113.3	1.042
13	112.4	"	108.4	113.3	1.037
14	116.2	Fracture	114.0	113.3	1.026
15	114.5	Pull-out	108.4	113.3	1.056
Average					0.983
Standard Deviation					0.054

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Table 3  
Minimum Joint Strength  
of  
Standard-Weight Threaded Line Pipe

Nominal Size	Outside Diameter D in.	Wall Thickness t in.	No. of Threads per in.	Engaged Thread L in.	Joint Strength			Strength Basis
					1000 lbs.			
					Grade			
				A25	A	B		
1/8	0.405	0.068	27	0.2726	1.65	1.77	2.21	Fracture
1/4	0.540	0.088	18	0.3945	2.52	2.69	2.36	"
3/8	0.675	0.091	18	0.4068	3.55	3.79	4.73	"
1/2	0.840	0.109	14	0.5342	4.97	5.30	6.63	"
3/4	1.050	0.133	14	0.5532	9.12	9.73	12.2	"
1	1.315	0.133	11 1/2	0.6610	10.0	10.7	13.4	"
1 1/4	1.660	0.140	11 1/2	0.6810	14.4	15.4	19.2	"
1 1/2	1.900	0.145	11 1/2	0.6810	16.8	18.9	22.9	Pull-out
2	2.375	0.154	11 1/2	0.6971	20.5	23.2	28.0	"
2 1/2	2.875	0.203	8	0.9320	33.2	37.4	45.3	"
3	3.500	0.216	8	1.0160	41.3	46.7	56.4	"
3 1/2	4.000	0.226	8	1.0710	47.9	54.3	65.5	"
4	4.500	0.237	8	1.0940	54.5	61.9	74.5	"
5	5.563	0.280 <sup>258</sup>	8	1.1870	69.4	79.2	95.1	"
6	6.626	0.280	8	1.2080	83.7	95.8	115	"
8	8.625	0.277	8	1.3130	93.1	107	128	"
8	8.625	0.322	8	1.3130	115	133	159	"
10	10.750	0.279	8	1.4600	106	122	146	"
10	10.750	0.307	8	1.4600	122	141	168	"
10	10.750	0.365	8	1.4600	154	178	213	"
12	12.750	0.330	8	1.6100	149	173	206	"
12	12.750	0.375	8	1.6100	177	205	244	"
14D	14.000	0.375	8	1.8120	195	226	283	"
16D	16.000	0.375	8	2.0620	218	253	301	"
18D	18.000	0.375	8	2.2500	237	376	328	"
20D	20.000	0.375	8	2.375	252	294	349	"

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