Yield and Proof Loads of Bolts

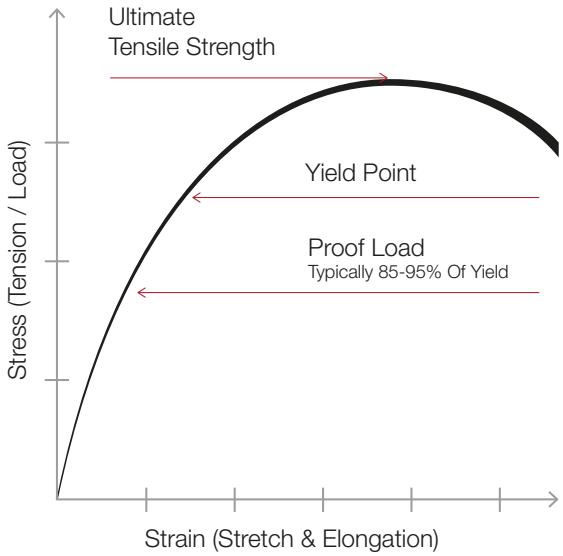
Differences between Yield Load, Proof Load, Ultimate Tensile Loads

When using bolts, it is important to know how their material properties change with different loads and forces. This is useful because it can tell us what happens before a bolt breaks.

Though steel bolts appear rigid, steel and a lot of other metals exhibit elastic behaviour. What this means is that the bolt will show a miniscule change in size and shape when a load is applied, but return to its normal state after it is removed.

However, this only happens up to a certain load. **Beyond this load, the bolt will permanently deform and will not return to its original state.** This load is called the **yield load** of the bolt. **Just before this yield load or yield point, where the bolt can return to its original state, it is called the 'elastic region'.**

Tensile Stress-Strain Diagram



After passing the yield point, the bolt will reach a **load at which it will break.** This is called the **Ultimate Tensile Load.**

The problem is that the yield load will cause permanent changes. So, it is more useful to have a parameter before reaching the yield point, where the bolt can still return to its normal state. For this reason, a value called 'proof load' is used for bolts and other engineering components. **Proof load is often between 85-95% of the yield load.**

The loading behavior of bolts can be shown in the graph below, showing proof load, yield point and ultimate tensile load.

Out of the three load categories, Ultimate Tensile Load is the largest value and Proof Load is the smallest value for any given bolt. So, proof load should be the first value that needs to be considered when analysing critical bolt behaviour.

Tables 1 and 2 show the proof loads for different metric bolts, both fine and coarse thread. **Tables 3 and 4** show the proof loads for different imperial bolts, both fine and coarse thread.

Table 1

Minimum Proof Loads — Metric Coarse Thread Bolts

			Minimal Ultimate Tensile Loads, N (Property classes 4.8 to 10.9)				
Nominal Bolt Size	Pitch, mm (Coarse)	Nominal stress area, mm^2	4.8	5.8	6.8	8.8	10.9
M3	0.50	5.03	1560	1910	2210	2920	4180
M3.5	0.60	6.78	2100	2580	2980	3940	5630
M4	0.70	8.78	2770	3340	3860	5100	7290
M5	0.80	14.2	4400	5400	6250	8230	11800
M6	1.00	20.1	6230	7640	8840	11600	16700
M7	1.00	28.9	8920	11000	127000	16800	24000
M8	1.25	36.6	11400	13900	161000	21200	30400
M10	1.50	58	18000	22000	25500	33700	48100
M12	1.75	84.3	26100	32000	37100	48900	70000
M14	2.00	115	35600	43700	50600	66700	95500
M16	2.00	157	48700	59700	69100	91000	130000
M18	2.50	192	59500	73000	84500	115000	159000
M20	2.50	245	76000	93100	108000	147000	203000
M22	2.50	303	93900	115000	133000	182000	252000
M24	3.00	353	109000	134000	155000	212000	293000
M27	3.00	459	142000	174000	202000	275000	381000
M30	3.50	561	174000	213000	247000	337000	466000
M33	3.50	694	215000	264000	305000	416000	570000
M36	4.00	817	253000	310000	359000	490000	678000
M39	4.00	976	303000	371000	429000	586000	810000

Table 2

Minimum Proof Loads — Metric Fine Thread Bolts

			Minimal Proof Loads, N (Property classes 4.8 to 10.9)				
Nominal Size	Pitch, mm (Fine)	Nominal Stress Area, mm^2	4.8	5.8	6.8	8.8	10.9
M8	1.00	39.2	12200	14900	17200	22700	32500
M10	1.00	64.5	19000	23300	26900	33500	50800
M10	1.25	61.2	20000	24500	28400	37400	53500
M12	1.25	92.1	27300	33500	38800	51100	73100
M12	1.50	88.1	28600	35000	40500	53400	76300
M14	1.50	125	38800	47500	55000	72500	104000
M16	1.50	167	51800	63500	73500	96900	139000
M18	1.50	216	67000	82100	95000	130000	179000
M20	1.50	272	84300	103000	120000	163000	226000
M22	1.50	333	103000	126000	146000	200000	276000
M24	2.00	384	119000	146000	169000	230000	319000
M27	2.00	496	154000	188000	218000	298000	412000
M30	2.00	621	192000	236000	273000	373000	515000
M33	2.00	761	236000	289000	335000	45700	632000
M36	3.00	865	268000	329000	381000	519000	718000
M39	3.00	1030	319000	391000	453000	618000	855000

Table 3

Minimum Proof Loads — Imperial Bolts (UNC)

Nominal Size, in	Stress area, mm^2	Minimum Proof Load (N)	
		Grade 5	Grade 8
1/4 – 20	20.51	12000	16900
5/16 – 18	33.80	19800	28000
3/8 – 16	49.99	29400	41400
7/16 – 14	68.60	40300	57000
1/2 – 13	91.54	53800	75700
9/16 – 12	117.40	69000	97000
5/8 – 11	145.80	85400	121000
3/4 – 10	215.48	126000	178000
7/8 – 9	298	175000	247000
1 – 8	391	229000	324000
1 1/8 – 7	492.3	251000	408000
1 1/4 – 7	625.16	319000	518000
1 3/8 – 6	745.16	380000	617000
1 1/2 – 6	906.44	463000	750000

Table 4

Minimum Proof Loads — Imperial Bolts (UNF)

Nominal Size, in	Stress area, mm^2	Minimum Proof Load (N)	
		Grade 5	Grade 8
1/4 – 20	20.51	13800	19400
5/16 – 18	33.80	21800	30900
3/8 – 16	49.99	33200	46700
7/16 – 14	68.60	44900	63200
1/2 – 13	91.54	60500	85400
9/16 – 12	117.40	77000	109000
5/8 – 11	145.80	97000	137000
3/4 – 10	215.48	141000	199000
7/8 – 9	298	193000	272000
1 – 8	391	251000	354000
1 1/8 – 7	492.3	282000	457000
1 1/4 – 7	625.16	353000	573000
1 3/8 – 6	745.16	433000	702000
1 1/2 – 6	906.44	521000	844000