

FATIGUE STRENGTH OF LARGE STEEL SCREW THREADS UNDER AXIAL LOADING

1. NOTATION

f_t	tensile strength of material	N/m ²	lbf/in ²
N	endurance		
S_a	alternating stress (that is, half the range of stress) based on core area	N/m ²	lbf/in ²
S_m	mean stress based on core area	N/m ²	lbf/in ²

Both SI and British units are quoted but any coherent system of units may be used.

2. NOTES

The results of about 160 fatigue tests on solid steel bolts and studs with nominal thread diameter equal to or greater than 1.5 in (38 mm) have been analysed to give curves of S_a/f_t against N .

The ranges of the experimental variables and other details are listed in Table 2.1.

TABLE 2.1

Variable		Figure 1	Figure 2
f_t for bolt or stud material		5 800 to 102 000 lbf/in ² (405 to 703 MN/m ²)	130 000 to 170 000 lbf/in ² (896 to 1170 MN/m ²)
Yield stress / f_t		0.46 to 0.66	0.7 to 0.85
S_m / f_t		0.15 to 0.4	0.2 to 0.5
Nominal thread diameter		2.0 to 3.0 in (51 to 76 mm)	1.5 to 5.06 in (38 to 129 mm)
Thread form		Whitworth type	Unified type
Finished root radius	cut or ground threads	0.137 of thread pitch	0.032–0.114 of thread pitch
	rolled threads	0.149–0.173 of thread pitch	0.136–0.16 of thread pitch
Method of thread manufacture (see Table 2.2)		A, B, E, and F	A, B and D
f_t for nut material		58 000 to 70 000 lbf/in ² (400 to 483 MN/m ²)	Not known
Test frequency		4.5 to 50 c/s (4.5 to 50 Hz)	Not known
Derivation (see Section 3)		1, 2, 3, 4, 5, 8	6, 7

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All tests were carried out at room temperature under a fluctuating tensile load. Care was taken to maintain axially of loading during the tests. All failures occurred in the threaded portion of the bolt or stud just inside the nut, close to the loaded face. Steel nuts of standard thickness were used in all cases. The results plotted are from unplated bolts.

The various methods of thread manufacture to which this Item refers are listed in Table 2.2.

TABLE 2.2

<i>Method</i>	<i>Description of method</i>	<i>Location of data</i>
A	Thread cut from fully heat treated material	Figures 1 and 2
B	Thread ground from fully heat treated material	Figures 1 and 2
D	Material of near nominal diameter fully heat treated before rolling of thread	Figure 2
E	Material fully heat treated, then surface ground before form-rolling of thread	Figure 1
F	Material fully heat treated then threads cut before root rolling	Figure 1

Each figure shows a mean line and a scatter band including 90 per cent of the results; these bands have been drawn so that 5 per cent of the results lie above the band and 5 per cent lie below. In Figure 1 the band is divided, as dictated by differences in the method of thread manufacture. Figure 2 also shows scatter bands for data from similar bolts not exceeding 1.0 in in diameter given in Item No. 84037, "Fatigue strength of external and internal steel screw threads under axial loading. (Standard forms not greater than 1.0 inch diameter.)".

For the results plotted here, differences between the two thread forms are not of practical significance.

The advantage of rolling the thread from fully heat treated material can be seen in Figure 1. The majority of rolled thread results shown in this figure are from bolts that had been root-rolled after machining of the thread form (Method F) and show no appreciable difference from the threads that had been fully form-rolled (Method E). Either process induces residual compressive stresses in the surface layers of the material at the root of the thread. The rolling process also tends to reduce the thickness at the thread root of any decarburised layer remaining after heat treatment. The surface finish is usually improved by rolling and, in the case of the results plotted in Figure 1, an increased root radius is provided by using a roller of section slightly larger than the standard root radius (see Table 2.1). All these effects and in addition the work hardening that occurs with some materials tend to increase the fatigue strength of the threads at long endurance.

In Figure 2 results are plotted from a limited number of tests on bolts ranging from 1.5 to 5.0 in diameter. The threaded portions of these bolts were either cut or ground to give root radii smaller than standard or rolled to give a range of root radii. Although there are no appreciable differences shown by these results other data suggest that a proportionately larger root radius is beneficial, see Item No. 67020, "Fatigue strength of steel screw threads with large root radii under axial loading".