

EFFECT OF INCLINED NUT SEATINGS ON THE FATIGUE STRENGTH OF STEEL SCREW THREADS (TENTATIVE)

1. NOTATION

A_c	core area of thread	m^2	in^2
f	equivalent stress in screw thread	N/m^2	lbf/in^2
f_{nom}	average stress on core area of thread, P/A_c	N/m^2	lbf/in^2
f_t	tensile strength of thread material	N/m^2	lbf/in^2
f_α	value of f_{nom} at which full contact of face of nut with seating first occurs	N/m^2	lbf/in^2
K	value of f/f_{nom} when nut is in point contact with seating		
N	endurance		
P	applied axial tensile load	N	lbf
S_a	equivalent alternating stress (that is, half the range of stress) based on core area	N/m^2	lbf/in^2
S_m	equivalent mean stress based on core area	N/m^2	lbf/in^2
α	angle of inclination of nut seating	deg	deg
<i>Suffixes:</i>			
max	at maximum load in the cycle		
min	at minimum load in the cycle		

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

2. INTRODUCTION

This Data Item gives a method of estimating the effect of an inclined nut seating on the fatigue strength of a steel screw thread.

The method is based on the calculation of an equivalent stress cycle that would produce the same endurance if the screw thread were loaded axially. The form of the relationship between equivalent and nominal stresses is derived from a simplified elastic theory; the values of K and f_α in the relationship are chosen with regard to available fatigue test results. Since values of K and f_α may vary rather widely, two sets of curves are presented, corresponding respectively to estimates of the 'best' and 'worst' conditions likely to occur in practice.

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The experimental results show that the actual behaviour of the type of connection considered here is much more complex than has been assumed for the purposes of this Data Item. For this reason the curves may be regarded only as a guide to what may occur in practice and the Item bears the designation 'Tentative'.

Information on the fatigue strength of axially loaded screw threads may be found in Items Nos 84037 and 67020.

3. SUMMARY OF EXPERIMENTAL VARIABLES

Approximate number of results : 480

Bolt diameters : 0.315 – 0.625 in (8 – 16 mm)

Approximate f_t : 123 000 – 180 000 lbf/in² (850 – 1240 MN/m²)

Approximate mean stress : 0.1 to 0.5 f_t

Thread series : BSF and DIN.

Nearly all the threads were cut but a few were rolled and the method of manufacture of the DIN threads is not known. A fluctuating tensile load cycle was applied in all cases. Steel nuts of conventional thickness were used and all failures occurred in the threaded portion of the bolt just inside the loaded face of the nut in the region of maximum tensile stress.

4. USE OF THE FIGURES

In Figures 1 and 2, f is plotted against f_{nom} for a range of values of α . The first figure represents the estimated worst conditions likely to occur in practice while the second figure is based on the most optimistic assumptions that could be made.

The unfavourable conditions represented in Figure 1 are approached most closely when

- (i) the bolt or stud is a close fit in the surrounding component
- (ii) the threads fit closely.

The conditions represented in Figure 2 occur when

- (i) the bolt or stud is fairly long and is installed with generous clearance or is of reduced diameter over its plain length
- (ii) the threads fit freely.

By use of either figure a nominal stress cycle imposed on a screw thread with a nut on an inclined seating may be converted to an equivalent stress cycle that would produce the same endurance if applied axially. Values of f_{nom} corresponding to the maximum and minimum loads in the cycle are first evaluated. From either figure, corresponding maximum and minimum values of f are obtained. The equivalent mean and alternating stresses are finally evaluated as

$$\begin{aligned} S_m &= \frac{1}{2}(f_{max} + f_{min}) \\ S_a &= \frac{1}{2}(f_{max} - f_{min}). \end{aligned} \quad (4.1)$$

These stresses may be used with data for axially loaded threads to estimate the endurance of a thread loaded through a nut on an inclined seating.

5. DERIVATION

The expressions:

$$\begin{aligned} f &= K f_{nom} & \text{for } f_{nom} \leq f_{\alpha} \\ \text{and } f &= f_{nom} + (K-1)f_{\alpha} & \text{for } f_{nom} \geq f_{\alpha}. \end{aligned}$$

1. Unpublished work by Vickers-Armstrongs (Aircraft) Ltd, 1958–1960.
2. ILLGNER, K.H. Einfluss überlagerter Biegung auf die Haltbarkeit von
BEELICH, K.H. Schraubenverbindungen. *Konstruktion*, Vol. 18, No. 3, pp. 117-124, 1966.
3. KIDDLE, F.E. Variation of bolt fatigue life with inclination of nut seating. RAE TR 67174, 1967.

6. EXAMPLE

It is required to estimate the fatigue endurance of a 3/8 – 24 UNF steel bolt under a fluctuating tensile load of 775 lbf for pre-tensions of zero, 775, 1550 and 2325 lbf. The nut seating has an inclination of 0.75°. The threads were cut in material heat treated to a final tensile strength of 125 000 lbf/in². The core area, $A_c = 0.0775 \text{ in}^2$.

Figure 1 will be used to give a conservative estimate.

In Table 6.1 the nominal stresses are evaluated for the four given load cycles. Maximum and minimum values of f are then obtained from Figure 1 and substituted in Equation (4.1) for S_m and S_a . In Table 6.2 S_m/f_t and S_a/f_t are evaluated and the corresponding mean endurance read from Figure 1 of Item No. 84037.

While the results indicate the beneficial effect of a high pre-tension on fatigue endurance the possibility of static or stress corrosion failure under the constant loading must also be considered.