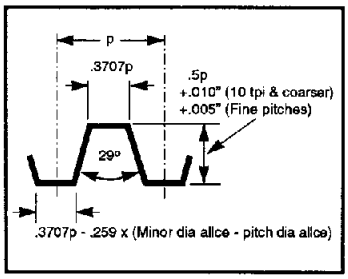
POWER SCREWS & NUTS

TYPES OF THREAD FORMS

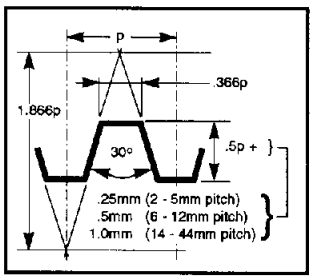
Unlike threaded fasteners which use Vee threads to develop a high frictional component in order to bolt parts together, the power screw and nut is intended to transmit power with a relative high efficiency. Referred to as 'threads of translation' the most frequently used basic forms are shown below.

Other forms of thread include the Buttress (BS1657, ANSI BS.9) used to resist large loads acting in only one direction and the Square Thread which owing to economic manufacturing advantages has been superseded by the Modified Square.



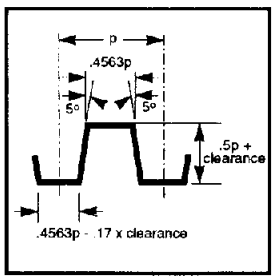
British and American Standard
GENERAL PURPOSE ACME
BS 1104, ANSI B1.5

A general purpose thread, economical to produce. Developed for use with machine tools they permit the use of a split nut.



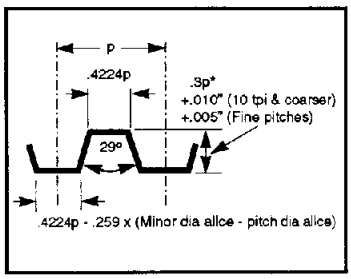
British and European
TRAPEZOIDAL
BS 5346, BS 4185 Pt10, DIN 103

The metric equivalent to the imperial ACME thread. BS4185 Pt10 refers specifically to machine tool lead screws.



American
MODIFIED SQUARE
NBS H-28

The 5° flank angle results in an ideal compromise practically equivalent to the square thread yet economical to produce.



American Standard
STUB ACME
ANSI B19

Offers a coarse pitch with a shallow depth *Modified Stub Forms 1 and 2 have ·375p and ·25p depths respectively

ACCURACY AND GRADE OF THREAD FIT

Prior to the adoption in 1977 of BS 4185:Pt10 :- Specification for Machine Tool Components - Trapezoidal threads for lead and feedscrew assemblies, apart from historical, random selection of clients bespoke pitch accuracies, the frequently accepted machine tool standard was G.Schlesinger "Testing Machine Tools".

The selection of a grade of thread fit to say ACME form controls allowances and tolerances of diametral clearances according to the application. These controls do relate to pitch accuracies but not specifically.

RELATED CLASSES OF ACCURACY AND GRADES OF SCREW THREAD FITS

BS 4185 : PT 10 Machine Tool Lead and Feed Screws			**BS 5346** I.S.O. Trapezoidal threads	BS 1104 (ANS B1 5) ACME screw threads	
Class of accuracy	**Pitch duration over 300mm**	**12"**	**Tolerance Grades**	**Class of threads**	**Application**
25	25μm	·0010"	**3e screw base or 4H nut base**	**5G**	No allowance on effective dia. Restricted to high precision assemblies with minimal clearances
(*30	30μm	·0012")			
40	40μm	·0016"			
† 60	60μm	·0024"			
100	100μm	·0040"	**3e / 4H**	**4G**	Close mating screw and nut threads. Restricted to where accuracy of pitch and thread form is required.
160	160μm	·0064"			
(* Schlesinger tolerance)			**6e / 6H (Fine)**	**† 3G**	Suitable for assemblies in which backlash or end play must not be excessive.
			† 7e / 7H (Medium)		
			8c / 8H (Coarse)	**2G**	Loose fit to allow free running even under exposed conditions.

Unless specified otherwise HR & S work to class/grade †. The above tables are an approximate comparison only.
Users are advised to consult the appropriate standard.

STRENGTH CONSIDERATIONS FOR LEADSCREW SHAFT AND NUT

A screwshaft is a rotating machine element used to transmit power that transforms rotary motion into linear motion. The screwshaft is therefore subject to both shear stress due to torsion and a tensile or compressive stress due to the load.

The theoretical stress analysis of screwshafts are at best only approximate, i.e. the load is assumed to be distributed uniformly over all the threads of engagement. However, research has shown that due to deflection, only the first few threads of engagement carry the major portion of the load. Depending on the elastic deformation within the screw-nut couple, the remaining threads carry lesser or greater portions of the load.

Hence the following accepted simple basis of calculation should embrace conservative, allowable stress values and suitable shock and fatigue factors for bending and torsion according to any bespoke industries or countries 'Code of Design Practice'.

It should also be noted that accepted good engineering design practice suggests the use of nuts whose lengths approximate from 1.5 to 2.5 times the major diameter of the screw. Nut lengths 3 times the major diameter should be considered as maximum. Any longer nut does not offer pro-rata strength benefits for reasons already mentioned and their cost of manufacture becomes uneconomical.

If the screwshaft is subject to a compressive stress and the unsupported length of the screw is ≥ 8 times the root diameter, then the screwshaft must be considered as a column, i.e. Reference should be made to the Ritter or J.B.Johnson formulas for 'short columns' and Euler for long columns. Suitable factors are applied according to the screwshaft end fixations.

CALCULATIONS FOR A LEADSCREW & NUT

1) Lead angle $\lambda = \text{Tan}^{-1}\left(\frac{\text{Lead}}{\pi d_2}\right)$

2) Torque required to exert force W (i.e. to raise load W)

$$T_R = \frac{Wd_2}{2}\left(\frac{\text{Cos}\,\alpha\,\text{Tan}\,\lambda + \mu}{\text{Cos}\,\alpha - \mu\,\text{Tan}\,\lambda}\right)$$

Note, torque required to lower load W

$$T_L = \frac{Wd_2}{2}\left(\frac{\mu - \text{Cos}\,\alpha\,\text{Tan}\,\lambda}{\text{Cos}\,\alpha + \mu\,\text{Tan}\,\lambda}\right)$$

3) Torsional shear stress on screw is: $\tau = \frac{16T}{\pi d_3^3}$

4) For screws in tension only (refer to column theory for shafts in compression)

Tensile stress on screw $\sigma = \frac{W}{A_3} = \frac{4W}{\pi d_3^2}$

*5) Resultant maximum shear stress on screwshaft

$$\tau_{max} = \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2} = \frac{0.637}{d_3^2}\sqrt{W^2 + \left(\frac{8T_R}{d_3}\right)^2}$$

Stress safety factor $= \frac{\cdot 5\,S_{yt}}{\tau_{max}}$

6) Minimum length of nut relative to the design bearing pressure P at the sliding velocity V where $V = \pi d_2$ RPM. Sec λ.

$$L_n = \frac{Wp}{\pi PhD_2} \leq 3d$$

7) Shear stress on root of threads

a) For screw $\tau_S = \frac{Wp}{\pi L_n d_3 F_{tS}}$ Safety Factor $= \frac{S_{YSS}}{\tau_S}$

b) For nut $\tau_N = \frac{Wp}{\pi L_n D_4 F_{tN}}$ Safety Factor $= \frac{S_{YSN}}{\tau_N}$

8) Efficiency of screw thread

$$e = \text{Tan}\,\lambda\left(\frac{\text{Cos}\,\alpha - \mu\,\text{Tan}\,\lambda}{\text{Cos}\,\alpha\,\text{Tan}\,\lambda + \mu}\right)$$

Note, if $\mu > \text{Cos}\,\alpha\,\text{Tan}\,\lambda$, the screw is self sustaining.

* Certain industry codes of practice require appropriate shock and fatigue factors Km, Kt when calculating the maximum shear stress, τ_{max} then becomes

$$\tau_{max} = \sqrt{\left(\frac{Km\,\sigma}{2}\right)^2 + \left(Kt\,\tau\right)^2}$$

NOTE: The allowable bearing pressure value P is dependent on the PV (pressure velocity) limitations of the Screw/Nut material combination for the operating conditioned and operating time cycles.

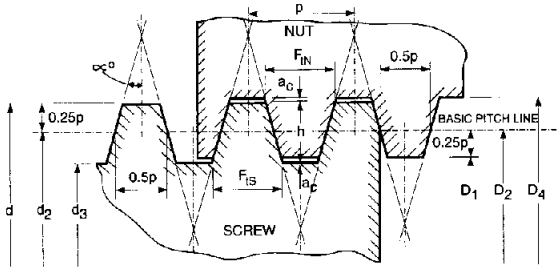
Typical values for steel screws and bronze nuts (lbf/in²)

Fly press	Low speed, well lubricated	2500-3500
Screw jack	Low speed up to 10 ft/min.	1600-2500
Hoist screw	Medium speed, 20 to 40 ft/min	800-1400
Lead screw	High speed, 50ft/min and over	150-240

NOTATION

α	Flank angle
λ	Lead angle
μ	Coefficient of friction (approx. 0.15)
σ	Tensile stress
τ	Shear stress
a_c	Crest clearance
A_3	Area of screw minor diameter d_3
d	Screw basic major diameter
d_2, D_2	Basic pitch diameter
d_3	Screw basic minor diameter
D_1	Nut basic minor diameter
D_4	Nut basic major diameter
F_{tN}	Nut root thread width
F_{tS}	Screw root thread width
h	Depth of thread engagement = 0.5p
L	Lead = number of starts x p
p	pitch
P	Allowable bearing pressure
S_{YSN}	Shearing yield strength of nut material
S_{YSS}	Shearing yield strength of screw material
S_{YT}	Tensile yield strength of screw material
W	Force

NOMINAL DESIGN PROFILE OF SCREW THREAD
(Typical full depth Acme/Trapezoidal)



· PREFERRED DIAMETER / PITCH COMBINATIONS ·

IMPERIAL ACME

Nominal Dia.	Pitch T.P.I. 10	8	6	(5)	4	3	2
1/2"	10						
5/8"		8					
3/4"			6				
7/8"			6				
1"			6	(5)			
1 1/8"				(5)	4		
1 1/4"				(5)	4		
1 3/8"					4		
1 1/2"					4		
1 3/4"					4		
2"					4		
2 1/4"						3	
2 1/2"						3	
2 3/4"						3	
3"							2
3 1/2"							2
4"							2

BS 1104 (ANSI B1.5)

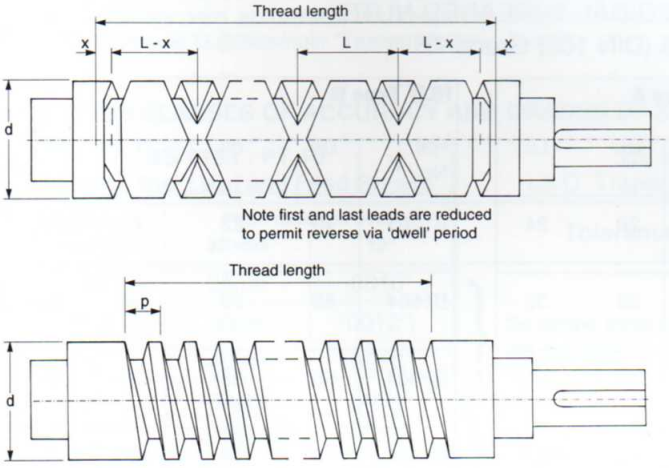
METRIC TRAPEZOIDAL

Preferred Nominal Dia. 1st.	2nd.	Pitch mm 2	3	3	5	6	7	8	9	10	12	14	16	18	20
12*		2	3												
16*		2		4											
	18	2		4											
20*		2		4											
	22		3		5			8							
(25)					(5)										
	30*		3			6				10					
32			3			6				10					
40*			3				7			10					
	50*		3					8			12				
	55		3						9		14				
60*			3						9		14				
	65			4						10			16		
70*				4						10			16		
80*				4						10			16		
90				4							12			18	
100*				4							12				20

BS 5346 Preferred BS 4185 : Pt 10 (only) * also.
Note BS 4185 offers a wider and differing choice of pitches.

SCREW PRODUCT RANGE

The photograph shows just a small sample from a wide range of leadscrews, feedscrews, jackscrews etc. that are manufactured within the following capacity



Screw thread capacity table

	Max pitch	Max dia.	Max. thread length
External threading	25mm (1")	160mm (6 1/4")	12.2m (40ft) Whirling
	* 25mm (1")	250mm(10")	5m (16ft) Milling
	* 25mm (1")	90mm (3 1/2")	7.5m (25ft) Milling
Internal threading	25mm (1")	250mm (10")	

* Leads up to 500 (20") for reverse traverse screws
Up to 8 start threads (screws and nuts)

STOCK SCREWS & NUTS

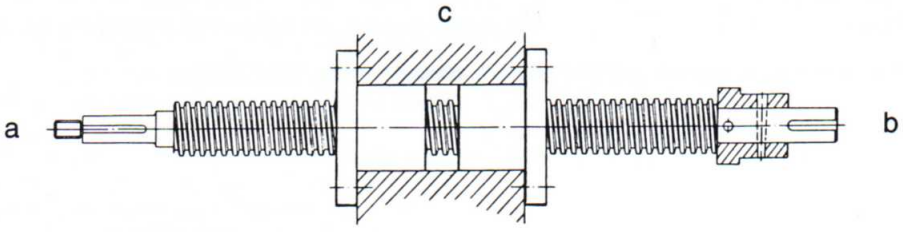
The continuing trend towards rationalisation and adherence to accepted standards has instigated Halifax Rack & Screw to manufacture and carry a stock range of steel power screws and phosphor bronze nuts.

This stock range, detailed overleaf, covers common metric trapezoidal thread sizes from 12 to 60 mm diameter using BS diameter and pitch combinations.

MODIFICATIONS TO STOCK SCREW NUTS

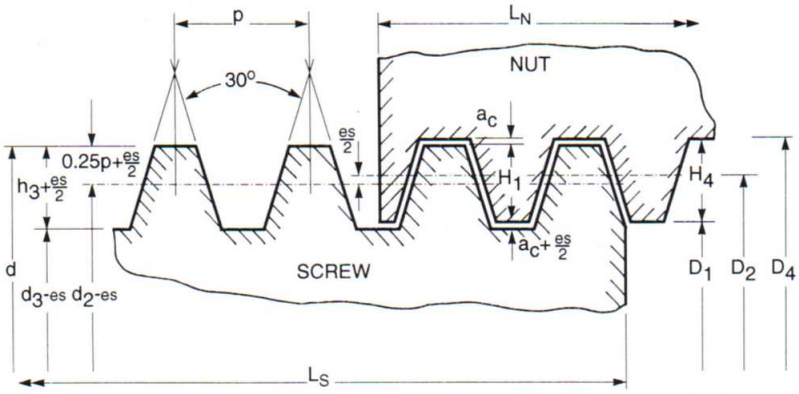
Standard stock items, as detailed overleaf, can be machined to suit finished requirements for example, stock screws can either have the ends machined down to suit journal bearings and keywayed etc, Fig a) or where larger journals are necessary, suitable sleeves can be pinned as shown in Fig b).

Stock nuts can be further machined to incorporate keyways, fine threads etc., (Type A) or holes drilled through the flanges (Type B). Flange nuts can easily be used to minimise backlash when mounted in pairs by either shimming or slotting holes in one nut Fig c).



STOCK SCREWS & NUTS

STOCK SCREWS & NUTS



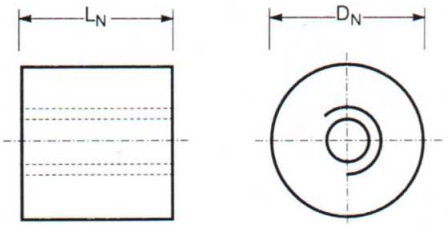
$H_1 = 0.5p$

$h_3 = 0.5p + a_c = H_1 + a_c = H_4$

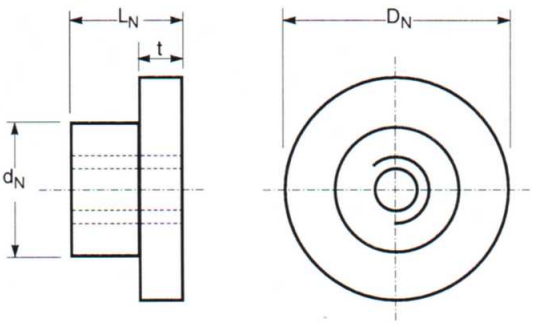
a_c = crest clearance

es = fundamental deviation

NUT Type A



NUT Type B



TRAPEZOIDAL THREADED SCREWS
BS 5346 (DIN 103) Grade 7e

SCREW					
Ref. No./ *	Thread Tr dxp	d2 max.	d2 min.	d3 min.	length Ls
12031 12032	12 x 3	10.415	10.191	8.14	1000 2000
16041 16042	16 x 4	13.905	13.640	11.07	1000 2000
20041 20042	20 x 4	17.905	17.640	15.07	1000 2000
25051 25052 25053	25 x 5	22.394	22.094	19.02	1000 2000 3000
32061 32062 32063	32 x 6	28.894	28.559	24.46	1000 2000 3000
40071 40072 40073	40 x 7	36.375	36.020	31.43	1000 2000 3000
50081 50082 50083	50 x 8	45.868	45.468	40.37	1000 2000 3000
60091 60092 60093	60 x 9	55.360	54.935	49.33	1000 2000 3000

* Suffix R - Right hand L - Left hand

Steel BS 080M40 (DIN Ck 40, SAE 1040)

TRAPEZOIDAL THREADED NUTS
BS 5346 (DIN 103) Grade 7H

NUT Type A		
Ref. No./ *	D_N	L_N
A1203	26	24
A1604	36	32
A2004	45	40
A2505	55	50
A3206	70	64
A4007	80	80
A5008	90	100
A6009	100	120

NUT Type B				
Ref. No./ *	D_N	d_N	t	L_N
B1203	40	22	7	22
B1604	52	30	10	30
B2004	58	35	11	35
B2505	70	45	13	45
B3206	90	55	15	56
B4007	120	65	18	70
B5008	150	80	20	90
B6009	170	95	25	110

* Suffix R - Right hand L - Left hand

Phosphor Bronze BS 1400 - PBI (DIN G-Cu Sn 10, SAE 65)

Stock screw threads whirled to lead tolerance of 0.06 / 300mm. Straightness ≤ 0.3 / 300mm.