**Linear Motion**

**Trapezoidal Leadscrew Nuts**
iglidur® Self Lubricating : DIN 103, ISO 2903

**Advantages**
- Self lubricating
- Resistant to dirt
- Maintenance free
- Best resistance to galling
- Corrosion free
- Quiet operation
- Temperature resistant up to +90°C
- Trapezoidal lead screws manufactured from Steel, Stainless and anodised Aluminium on request.
- Left-handed leadscrew nuts on request.

Until now, there have been two types of trapezoidal lead screw nuts on the market; lubricated metallic nuts (Steel, Bronze, Brass etc.) without emergency running properties, and maintenance free versions made of plastic such as PA 6.6 or POM with very restricted load capacity. iglidur® maintenance free trapezoidal lead screw nuts are now closing the gap - they are fully maintenance free and take high loads.

The new Trapezoidal lead screw nuts add to the range of the maintenance free and dry running products for linear technology.
The iglidur® lead screw nuts offer considerable advantages over nuts which require maintenance and lubrication especially in applications using detergents such as those of the packaging industry or in areas with high dust contamination (textile machines).

The iglidur® lead screw nuts are manufactured to DIN 103.

**Calculations of the trapezoidal thread loads**
The load capacity of the trapezoidal lead screw nuts made of high performance polymers depends on the surface pressure, the speed and the resulting temperature.

The temperature ratio will be affected by the frequency as well as by the lead screw material and its thermal properties.

The surface pressure of the iglidur® trapezoidal lead screw nut should not permanently exceed 5 MPa.

\[ p \times v \leq \text{Value}_{max} \leq 0.08 \text{ MPa} \times \text{m/s} \]

The permissible feeds and speeds can be determined for each thread size with the pxv value and the running surfaces given in the dimension table.

Required (running surface):
- \( A_{e} = \frac{F_{axial}}{P_{permissible}} \) (mm²)

Selection of the thread size and determination of the effective surface pressure:
- \( P_{eff} = \frac{F_{axial}}{A_{e} \text{ eff}} \) (MPa)

Permissible sliding speed:
- \( V_{slide} = \frac{p \times v_{max}}{P_{eff}} \) (m/s)

Maximum permissible RPM:
- \( N = \frac{V_{slide} \times 1.000 \times 60}{(\pi \times d_{1})} \) (1/mm)

Feed Speed:
- \( V_{feed} = \frac{n \times P}{60.000} \) (m/s)

\[ \begin{align*}
    F_{axial} & \quad \text{Axial force} \\
    P_{permissible} & \quad \text{Max. permissible surface pressure 5 MPa} \\
    P_{eff} & \quad \text{Effective surface pressure on a specific thread size} \\
    A_{e} \text{ eff} & \quad \text{Effective supporting surface of the selected trapezoidal lead screw nut} \\
    P & \quad \text{Pitch} \\
    d_{1} & \quad \text{Effective diameter}
\end{align*} \]
**LINEAR MOTION**

Trapezoidal Leadscrews

**Dimensions of Screw and Nut**
The screw has to withstand the applied torque and also carry the load. The length of engagement between the nut and screw must be sufficient to avoid shearing and too rapid wear. In practice, it is nearly always the latter which determines the length of nut. The screw, if in compression, will also have to be considered as a column, and the J.B. Johnson or Euler formula applied. Since the torque is a function of the pitch diameter, which itself cannot be calculated until the minor diameter is known, the screw diameter must be selected by a trial and error solution. Therefore a trial solution for the minor diameter area is made considering only the normal stress. Use the following equation;

\[ A_i = \frac{W x f_s}{S_y} \]

Then a nominal thread is selected having a minor diameter equal to, or exceeding that calculated. It is now possible to ascertain the tangent of the helix angle;

\[ \tan \lambda = \frac{P}{\pi d} \]

With this information the torque can be calculated;

\[ T = \frac{Wd}{2} \left( \frac{\cos \alpha \tan \lambda + \mu}{\cos \alpha - \mu \tan \lambda} \right) \]

The next step is to find the torsional shear stress;

\[ S_s = \frac{16T}{\pi d_i^3} \]

And the normal stress on the minor diameter section for screws in tension;

\[ S = \frac{W}{A_i} \]

For screws in compression, we must take into account the bending stresses, since the screw is acting as a column, and J.B. Johnson or Euler formula will apply. Use the following equation to determine which formula is applicable;

\[ a) L < \frac{2C\pi^2E}{K_S} \quad b) L > \frac{2C\pi^2E}{K_S} \]

If a) applies, then the screw conforms to the Johnson formula;

\[ S = \frac{W}{A_i} \left[ 1 - \frac{1}{\sqrt{\frac{S_y}{4C\pi^2E}}} \right] \]

If b) applies, then the screw conforms to the Euler formula;

\[ S = \frac{W}{A_i} \left( \frac{S_y}{4\pi^2E} \right) \]

Having obtained a value for 'S' from one of the above equations a solution can be made for the factor of safety, taking into account all the stresses.

**Graph of Speed/Allowable Pressure**

Steel screws and bronze or cast iron nuts only

\[ f_s = \frac{S_y/2}{\left( \frac{S_y}{2} + S_s \right)^2} \]

This is then compared with the originally selected design value, and a decision can be made as to whether this is adequate, or whether another solution must be calculated.

It is advisable to check at this stage the length of the nut necessary to give acceptable bearing pressure on the thread flanks to ensure a satisfactory service life;

\[ L_e = \frac{\pi B}{(d_o - d_i)^2} \]

The length of the nut should not exceed 3d, or manufacturing difficulties will arise, and if the nut length is found to be excessive, then re-calculation will be necessary using a larger screw diameter and alternative pitch. A multiple start thread will reduce the pitch-line sliding speed, and this alone may solve the problem of excessive bearing pressure. Finally, a check should be made on the factor of safety provided by the screw threads in shear;

\[ \text{Screw } f_s = \frac{L_e \pi d_i S_y}{W_p} \quad \text{Nut } f_s = \frac{L_e \pi d_o S_y}{W_p} \]

**Efficiency of a Screw Thread**

\[ e = \tan \lambda \left( \frac{\cos \alpha - \mu \tan \lambda}{\cos \alpha + \mu} \right) \]

**Self Locking Threads**

A screw will be self-sustaining if \( \mu > \cos \mu \tan \lambda \).

**Symbols Used in Equations**

\[ A_i = \text{Area of screw minor diameter} \]
\[ B = \text{Allowable bearing pressure (see graph)} \]
\[ C = \text{End fixity coefficient (C = 2 for fixed ends)} \]
\[ d = \text{Effective diameter of thread} \]
\[ d_i = \text{Minor diameter of thread} \]
\[ d_o = \text{Major diameter of thread} \]
\[ E = \text{Modulus of elasticity of material} \]
\[ f_s = \text{Factor of safety} \]
\[ I = \text{Second moment of inertia} \]
\[ K = \sqrt{\frac{I}{A_i}} \quad \text{radius of gyration of cross-section} \]
\[ L = \text{Length of shaft, unsupported} \]
\[ L_e = \text{Length of engagement} = \text{length of nut} \]
\[ L_p = \text{Pitch of thread} \]
\[ P = \text{Lead of thread (pitch x No. of starts)} \]
\[ S_s = \text{Torsional shear stress} \]
\[ S_y = \text{Shear stress yield point of material} \]
\[ S = \text{Shear stress yield point of material} \]
\[ S_{sy} = \text{Shear stress yield point of material} \]
\[ T = \text{Torque} \]
\[ \tau_i = \text{Thread thickness, minor diameter} \]
\[ \tau_o = \text{Thread thickness, major diameter} \]
\[ W_l = \text{Axial load} \]
\[ \lambda = \text{Helix angle} \]
\[ \alpha = \text{Flank angle (15° Trapezoidal)} \]
\[ \mu = \text{Coefficient of friction (can be taken as 0.15)} \]
Load v Speed (Steel screws with Bronze nuts) (May need correction for nut length (lg))

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<thead>
<tr>
<th>Linear speed (mm/min)</th>
<th>Tr 12 x 3</th>
<th>Tr 16 x 4</th>
<th>Tr 20 x 4</th>
<th>Tr 24 x 5</th>
<th>Tr 32 x 6</th>
<th>Tr 40 x 6</th>
<th>Tr 50 x 8</th>
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Bucking Load v Screw Length

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<th>Thread Dimensions</th>
<th>Perm-tensile Force (Kg)</th>
<th>Screw Length (m)</th>
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The Process
Cold-formed threading, more commonly called rolling, implies the cold forming of a metal bar by pressing during rotation with tools called dies, in order to obtain a thread or a knurling. Thanks to this performing process, we manufacture amongst others metric, trapezoidal threads and ball screws, using different materials such as current and special steels, stainless steel, brass and numerous alloys.

Economic Efficiency
The process of rolling allows high production and an important saving in material as the diameter used is below nominal and unlike cutting it has no chips, thus no material loss.

Comparisons
The roller finishing on the surface considerably increases the life time of the screw or of the nut, improves fatigue strength and eliminates the starting points of the fracture.

Improvement of the Mechanical Properties: Gain reaching 30% on hardness and 12% on breaking strength, in fact the fibres of the material are formed but not cut in the case of cutting.