The SKF brand now stands for more than ever before, and means more to you as a valued customer.

While SKF maintains its leadership as the hallmark of quality bearings throughout the world, new dimensions in technical advances, product support and services have evolved SKF into a truly solutions-oriented supplier, creating greater value for customers.

These solutions encompass ways to bring greater productivity to customers, not only with breakthrough application-specific products, but also through leading-edge design simulation tools and consultancy services, plant asset efficiency maintenance programmes, and the industry’s most advanced supply management techniques.

The SKF brand still stands for the very best in rolling bearings, but it now stands for much more.

SKF – the knowledge engineering company

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>3</td>
</tr>
<tr>
<td>Recommendations</td>
<td>4</td>
</tr>
<tr>
<td>Selection</td>
<td>4</td>
</tr>
<tr>
<td>Basic dynamic load rating</td>
<td>4</td>
</tr>
<tr>
<td>Static load carrying capacity</td>
<td>5</td>
</tr>
<tr>
<td>Critical rotating speed for screw shafts</td>
<td>5</td>
</tr>
<tr>
<td>Permissible speed limit</td>
<td>5</td>
</tr>
<tr>
<td>Efficiency and back-driving</td>
<td>6</td>
</tr>
<tr>
<td>Axial play and preload</td>
<td>6</td>
</tr>
<tr>
<td>Static axial stiffness of a complete assembly</td>
<td>7</td>
</tr>
<tr>
<td>Screw shaft buckling</td>
<td>7</td>
</tr>
<tr>
<td>Manufacturing precision</td>
<td>8</td>
</tr>
<tr>
<td>Materials and heat treatments</td>
<td>8</td>
</tr>
<tr>
<td>Number of circuits of balls</td>
<td>8</td>
</tr>
<tr>
<td>Assembly procedure</td>
<td>9</td>
</tr>
<tr>
<td>Radial and moment loads</td>
<td>9</td>
</tr>
<tr>
<td>Alignment</td>
<td>9</td>
</tr>
<tr>
<td>Lubrication</td>
<td>9</td>
</tr>
<tr>
<td>Designing the screw shaft ends</td>
<td>9</td>
</tr>
<tr>
<td>Starting-up the screw</td>
<td>9</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>9</td>
</tr>
<tr>
<td>Technical data</td>
<td>10</td>
</tr>
<tr>
<td>Lead precision according to ISO</td>
<td>10</td>
</tr>
<tr>
<td>Geometric tolerance</td>
<td>11</td>
</tr>
<tr>
<td>Design and functional specifications</td>
<td>14</td>
</tr>
<tr>
<td>Geometric profile of the track/ball area</td>
<td>14</td>
</tr>
<tr>
<td>Preload</td>
<td>14</td>
</tr>
<tr>
<td>Materials and thermal expansions</td>
<td>15</td>
</tr>
<tr>
<td>Checking of the maximum axial operating load</td>
<td>16</td>
</tr>
<tr>
<td>Application of precision ball screw</td>
<td>17</td>
</tr>
<tr>
<td>Product information</td>
<td>18</td>
</tr>
<tr>
<td>Ordering key</td>
<td>18</td>
</tr>
<tr>
<td>PGFJ Flanged nut with internal preload, DIN standard</td>
<td>19</td>
</tr>
<tr>
<td>PGFL Double preloaded flanged nut long lead</td>
<td>20</td>
</tr>
<tr>
<td>PGFE Double preloaded flanged nut</td>
<td>21</td>
</tr>
<tr>
<td>PGCL Cylindrical double preloaded nut</td>
<td>24</td>
</tr>
<tr>
<td>Standard end machined</td>
<td>26</td>
</tr>
<tr>
<td>End bearings</td>
<td>27</td>
</tr>
<tr>
<td>Product Inspection and certification</td>
<td>28</td>
</tr>
<tr>
<td>How to orientate your choice</td>
<td>30</td>
</tr>
<tr>
<td>Calculation formulas</td>
<td>32</td>
</tr>
</tbody>
</table>

SKF – the knowledge engineering company
SKF BSS

SKF BSS, to accomplish its overall set of goal, has take part of the 75 years tradition of Gamflor, the precision mechanical manufacturing Italian company. Sharing knowledge and highly qualified experience, is the SKF way of stay in front of the increasingly fast technical-production developments of the market.

To inherit the Italian company, as an integral part of its organisation, represents in fact a further step of SKF’s improving processes in the technical high precision production of ball screws.

This Italian business unit (or division) comprises buildings and departments covering 16 000 sq. mts.

The production environment, plunged in a plantation of about a thousand conifers, reflects the SKF responsibility of it’s human resources offering safe and good working conditions.

In effect SKF is committed to creating an environment where the skill and experience of the operator is decisive, side by side with foreman NC machines, computers systems and CAD systems.

The most significant aspect of that Italian b.u. is the integrated development of the production, including its mechanical and electronic components, which provides the ideal basis for contacts with the customer.
2 Recommendations

Selection

Recommendations

NB.: Only basic selection parameters are included. To make the very best selection of a ball screw, the designer should specify such critical parameters as the load profile, the linear or rotational speed, the rates of acceleration and deceleration, the cycle rate, the environment, the required life, the lead accuracy, the stiffness, and any other special requirement. If in doubt, please consult an SKF ball screw specialist before placing an order.

Basic dynamic load rating (Cₗ)

The dynamic rating is used to compute the fatigue life of ball screws. It is the axial load constant in magnitude and direction, and acting centrally under which the nominal life (as defined by ISO) reaches one million revolutions.

Nominal fatigue life L₁₀

The nominal life of a ball screw is the number of revolutions (or the number of operating hours at a given constant speed) which the ball screw is capable of enduring before the first sign of fatigue (flaking, spalling) occurs on one of the rolling surfaces.

It is however evident from both laboratory tests and practical experience that seemingly identical ball screws operating under identical conditions have different lives, hence the notion of nominal life. It is, in accordance with ISO definition, the life achieved or exceeded by 90 % of a sufficiently large group of apparently identical ball screws, working in identical conditions (alignment, axial and centrally applied load, speed, acceleration, lubrication, temperature and cleanliness).

Service life

The actual life achieved by a specific ball screw before it fails is known as “service life”. Failure is generally by wear, not by fatigue (flaking or spalling); wear of the recirculation system, corrosion, contamination, and, more generally, by loss of the functional characteristics required by the application. Experience acquired with similar applications will help to select the proper screw to obtain the required service life. One must also take into account structural requirements such as the strength of screw ends and nut attachments, due to the loads applied on these elements in service.

Equivalent dynamic loads

The loads acting on the screw can be calculated according to the laws of mechanics if the external forces (e.g. power transmission, work, rotary and linear inertia forces) are known or can be calculated. It is necessary to calculate the equivalent dynamic load: this load is defined as that hypothetical load, constant in magnitude and direction, acting axially and centrally on the screw which, if applied, would have the same influence on the screw life as the actual loads to which the screw is subjected.

Radial and moment loads must be taken by linear bearing systems. It is extremely important to resolve these problems at the earliest conceptual stage. These forces are detrimental to the life and the expected performance of the screw.

Fluctuating load

When the load fluctuates during the working cycle, it is necessary to calculate the equivalent dynamic load: this load is defined as that hypothetical load, constant in magnitude and direction, acting axially and centrally on the screw which, if applied, would have the same influence on the screw life as the actual loads to which the screw is subjected. Additional loads due, for example to misalignment, uneven loading, shocks, and so on, must be taken in account. Their influence on the nominal life of the screw is generally taken care of, consult SKF for advice.
Static load carrying capacity (\(C_{oa}\))

Ball screws should be selected on the basis of the basic static load rating \(C_{oa}\) instead of bearing life when they are submitted to continuous or intermittent shock loads, while stationary or rotating at very low speed for short duration. The permissible load is determined by the permanent deformation caused by the load acting at the contact points. It is defined by ISO standards as the purely axially and centrally applied static load which will create, by calculation, a total (rolling element + thread surface) permanent deformation equal to 0.0001 of the diameter of the rolling element.

A ball screw must be selected by its basic static load rating which must be, at least, equal to the product of the maximum axial static load applied and a safety factor “so”. The safety factor is selected in relation with past experience of similar applications and requirements of running smoothness and noise level\(^{(1)}\).

Critical rotating speed for screw shafts

The shaft is equated to a cylinder, the diameter of which is the root diameter of the thread. The formulas use a parameter the value of which is dictated by the mounting of the screw shaft (whether it is simply supported or fixed). As a rule the nut is not considered as a support of the screw shaft. Because of the potential inaccuracies in the mounting of the screw assembly, a safety factor of 80 is applied to the calculated critical speeds.

Calculations which consider the nut as a support of the shaft, or reduce the safety factor, require practical tests and possibly an optimization of the design\(^{(1)}\).

Permissible speed limit

The permissible speed limit is that speed which a screw cannot reliably exceed at any time. It is generally the limiting speed of the recirculation system in the nut. It is expressed as the product of the rpm and the nominal diameter of the screw shaft (in mm).

The speed limits quoted in this catalogue are the **maximum speeds that may be applied through very short periods** and in optimized running conditions of alignment, light external load and preload with monitored lubrication. Running a screw continuously at the permissible speed limit may lead to a reduction of the calculated life of the nut mechanism.

The lubrication of screws rotating at high speed must be properly considered in quantity and quality. The volume, spread and frequency of the application of the lubricant (oil or grease) must be properly selected and monitored. At high speed the lubricant spread on the surface of the screw shaft may be thrown off by centrifugal forces. It is important to monitor this phenomenon during the first run at high speed and possibly adapt the frequency of re-lubrication or the flow of lubricant, or select a lubricant with a different viscosity. Monitoring the steady temperature reached by the nut permits the frequency of re-lubrication or the oil flow rate to be optimized.

\(^{(1)}\) SKF can help you to define this value in relation with the actual conditions of service.

ATTENTION!:

High speed associated with high load requires a large input torque and yields a relatively short nominal life\(^{(1)}\).

In the case of high acceleration and deceleration, it is recommended to either work under a nominal external load or to apply a light preload to the nut to avoid internal sliding during reversal. The value of preload of screws submitted to high velocity must be that preload which ensures that the rolling elements do not slide\(^{(1)}\).

Too high a preload will create unacceptable increases of the internal temperature.
Efficiency and back-driving

The performance of a screw is mainly dependant on the geometry of the contact surfaces and their finish as well as the helix angle of the thread. It is, also, dependant on the working conditions of the screw (load, speed, lubrication, preload, alignment, etc...).

The "direct efficiency" is used to define the input torque required to transform the rotation of one member into the translation of the other. Conversely, the "indirect efficiency" is used to define the axial load required to transform the translation of one member into the rotation of the other one. It is used, also, to define the braking torque required to prevent that rotation.

It is safe to consider that these screws are reversible or back-drivable under almost all circumstances. It is therefore necessary to design a brake mechanism if backdriving is to be avoided (gear reducers or brake).

Preload torque:
Internally preloaded screws exhibit a torque due to this preload. This persists even when they are not externally loaded. Preload torque is measured at 100 rpm (without wipers) when assembly is lubricated with ISO grade 68 oil.

Starting torque:
This is defined as the torque needed to overcome the following to start rotation:
- a) the total inertia of all moving parts accelerated by the energy source (including rotation and linear movement).
- b) the internal friction of the screw/nut assembly, bearing and associated guiding devices.

In general, torque to overcome inertia (a) is greater than friction torque (b).

The coefficient of friction of the high efficiency screw when starting $\mu_s$ is estimated at up to double the dynamic coefficient $\mu$, under normal conditions of use.

Axial play and preload

Preloaded nuts are subject to much less elastic deformation than non-preloaded nuts. Therefore they should be used whenever the accuracy of positioning under load is important.

Preload is that force applied to a set of two half nuts to either press them together or push them apart with the purpose of eliminating backlash or increasing the rigidity or stiffness of the assembly. The preload is defined by the value of the preload torque (see under that heading in the previous paragraph). The torque depends on the type of nut and on the mode of preload (elastic or rigid).

Preload systems

Fig. 1

---

**Preload systems**

<table>
<thead>
<tr>
<th>Screw</th>
<th>Lead</th>
<th>Nut</th>
<th>Lead</th>
<th>Lead + Shift</th>
<th>PGFJ</th>
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<th>Screw</th>
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<th>Nut</th>
<th>PGCL</th>
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<th>PGFE</th>
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</table>
Static axial stiffness of a complete assembly

It is the ratio of the external axial load applied to the system and the axial displacement of the face of the nut in relation with the fixed (anchored) end of the screw shaft. The inverse of the rigidity of the total system is equal to the sum of all the inverses of the rigidity of each of the components (screw shaft, nut as mounted on the shaft, supporting bearing, supporting housings, etc...).

Because of this, the rigidity of the total system is always less than the smallest individual rigidity.

Nut rigidity

When a preload is applied to a nut, firstly, the internal play is eliminated, then, the Hertzian elastic deformation increases as the preload is applied so that the overall rigidity increases. The theoretical deformation does not take into account machining inaccuracies, actual sharing of the load between the different contact surfaces, the elasticity of the nut and of the screw shaft. The practical stiffness values given in the catalogue are lower than the theoretical values for this reason. The rigidity values given in the SKF ball screw catalogue are individual practical values for the assembled nut. They are determined by SKF based on the value of the selected basic preload and an external load equal to twice this preload.

Elastic deformation of screw shaft

This deformation is proportional to its length and inversely proportional to the square of the root diameter.

According to the relative importance of the screw deformation (see rigidity of the total system), too large an increase in the preload of the nut and supporting bearings yields a limited increase of rigidity and notably increases the preload torque and therefore the running temperature. Consequently, the preload stated in the catalogue for each dimension is optimum and should not be increased.

Screw shaft buckling

The column loading of the screw shaft must be checked when it is submitted to compression loading (whether dynamically or statically). The maximum permissible compressive load is calculated using the Euler formulas. It is then multiplied by a safety factor of 3 to 5, depending on the application.

The type of end mounting of the shaft is critical to select the proper coefficients to be used in the Euler formulas.

When the screw shaft comprises a single diameter, the root diameter is used for the calculation. When the screw comprises different sections with various diameters, calculations becomes more complex (1).

---

(1) SKF can help you to define this value in relation with the actual conditions of service.
2 Recommendations
Selection

Manufacturing precision
	Generally speaking, the precision indication given in the designation defines the lead precisions see page 11 – lead precision according to ISO – (e.g. G5 - G3...).
	Parameters other than lead precision correspond to our internal standards (generally based on ISO class 5).
	If you require special tolerances (for example class 5) please specify when requesting a quotation or ordering.

Materials and heat treatments
	Standard screw shafts are machined from steel which is surface hardened by induction (C48 or equivalent).
	Standard nuts are machined in steel which is carburized and through hardened (18 Ni CrMo5 or equivalent).
	Hardness of the contact surfaces is 59-62 HRC, depending on diameter, for standard screws.

Number of circuits of balls
	A nut is defined by the number of ball turns which support the load.
	The number is changing, according to the product and the combination diameter/lead.
	It is defined by the number of circuits and their type.

Working environment
	Our products have not been developed for use in an explosive atmosphere, consequently we cannot take any responsibility for the use in this field.
Assembly procedure

Radial and moment loads

Any radial or moment load on the nut will overload some of the contact surfaces, thus significantly reducing its life.

Alignment

SKF linear guidance components should be used to ensure correct alignment and avoid non-axial loading.

The parallelism of the screw shaft with the guiding devices must be checked. If external linear guidance prove impractical, we suggest mounting the nut on trunnions or gimbals and the screw shaft in self-aligning bearings.

Mounting the screw in tension helps align it properly and eliminates bucking.

Lubrication

Good lubrication is essential for the proper functioning of the screw and for its long term reliability. Before shipping, the screw is coated with a protective fluid that dries to a film. This protective film is not a lubricant.

Depending on the selected lubricant, it may be necessary to remove this film before applying the lubricant (there may be a risk of non-compatibility).

If this operation is performed in a potentially polluted atmosphere it is highly recommended to proceed with a thorough cleaning of the assembly.

Designing the screw shaft ends

Generally speaking, when the ends of the screw shaft are specified by the customer’s engineering personnel, it is their responsibility to check the strength of these ends. However, we offer in pages 16 and 17 of this catalogue, a choice of standard machined ends. As far as possible, we recommend their use.

Whatever your choice may be, please keep in mind that no dimension on the shaft ends can exceed \( d_0 \) (otherwise traces of the root of thread will appear or the shaft must be made by joining 2 pieces).

A minimum shoulder should be sufficient to maintain the internal bearing.

Starting-up the screw

After the assembly has been cleaned, mounted and lubricated, it is recommended that the nut is allowed to make several full strokes at low speed; to check the proper positioning of the limit switches or reversing mechanism before applying the full load and the full speed.

Operating temperature

Screws made from standard steel and operating under normal loads can sustain temperatures in the range \(-10 \, ^\circ C \div +70 \, ^\circ C\).

Above 70 °C, materials adapted to the temperature of the application should be selected. Consult SKF for advice.

Note:

Operating at high temperature will lower the hardness of the steel, alter the accuracy of the thread and may increase the oxidability of the materials.

Assembly procedure

Note:

Ground ball screws are precision components and should be handled with care to avoid shocks. When stored out of the shipping crate they must lie on wooden or plastic vee blocks and should not be allowed to sag.

Screw assemblies are shipped, wrapped in a heavy gauge plastic tube which protects them from foreign material and possible pollution. They should stay wrapped until they are used.
Technical data

Lead precision according to ISO

Lead precision is measured at 20 °C on the useful stroke \( l_u \), which is the threaded length decreased, at each end, by the length \( l_e \) equal to the screw shaft diameter see (➔ table 1) and (➔ fig. 1).

### Technical data

<table>
<thead>
<tr>
<th>G1</th>
<th>G3</th>
<th>G5</th>
</tr>
</thead>
<tbody>
<tr>
<td>V300p, ( \mu m )</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>( l_u )</td>
<td>( e_p )</td>
<td>( v_{up} )</td>
</tr>
<tr>
<td>mm</td>
<td>( \mu m )</td>
<td>( \mu m )</td>
</tr>
<tr>
<td>0 - 315</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>(315) - 400</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>(400) - 500</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>(500) - 630</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>(630) - 800</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>(800) - 1000</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>(1000) - 1250</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>(1250) - 1600</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>(1600) - 2000</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>(2000) - 2500</td>
<td>19</td>
<td>13</td>
</tr>
<tr>
<td>(2500) - 3150</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>(3150) - 4000</td>
<td>23</td>
<td>16</td>
</tr>
</tbody>
</table>

\( l_u \) = useful travel  
\( l_e \) = excess travel (no lead precision required)  
\( l_0 \) = nominal travel  
\( l_s \) = specified travel  
\( c \) = travel compensation (difference between \( l_s \) and \( l_0 \) to be defined by the customer, for instance to compensate an expansion)

Case with value of \( c \) specified by the customer

Case with \( c = 0 \) = standard version in case of no value given by the customer
Geometric tolerances

Run-out tolerances (➔ table 2)
Tolerances tighter than the currently applicable ISO/TC39/WG7 specifications and the Internal Draft Standard ISO/DIS 3408-3 (➔ fig. 4). The division into ISO accuracy classes ISO 1 (➔ table 3), ISO 3 (➔ table 4), ISO 5 (➔ table 5) and ISO 7 (➔ table 6) refers, however, to these standards.

![Fig. 4](image-url)

**Run-out tolerances - Maximum permissible deviations**

<table>
<thead>
<tr>
<th>Position “t1 – t2”</th>
<th>Position “t9”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial run-out of the diameter of bearing seat in relation to reference supports</td>
<td>Radial run-out of the location diameter of the nut in relation to the reference supports</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Position “t3 – t4 – t5”</th>
<th>Position “t10”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial run-out of the diameter of the end of the screw in relation to bearings seats</td>
<td>Deviation of the parallelism of the mounting surfaces of the nut in relation to the reference supports</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Position “t6 – t7”</th>
<th>Position “t11”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial run-out of the faces of the bearing seat in relation to reference supports</td>
<td>Radial run-out of the free ends with rigidity blocked nut</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Position “t8”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial run-out of the ball nut location face in relation to the reference supports</td>
</tr>
</tbody>
</table>
### Table 3

#### ISO 1 - Dimensions in mm

<table>
<thead>
<tr>
<th>d₁</th>
<th>Tolerance</th>
<th>( L_n )</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 ... 50</td>
<td>0.005 ... 0.029</td>
<td>50 ... 300</td>
<td>0.005 ... 0.029</td>
</tr>
<tr>
<td>300 ... 500</td>
<td>0.029 ... 0.048</td>
<td>0.029 ... 0.048</td>
<td></td>
</tr>
<tr>
<td>500 ... 1 000</td>
<td>0.048 ... 0.096</td>
<td>0.048 ... 0.096</td>
<td></td>
</tr>
</tbody>
</table>

\[
t = \frac{L_n \times 0.012}{125}
\]

<table>
<thead>
<tr>
<th>d₁</th>
<th>Tolerance</th>
<th>( L_0 )</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 ... 100</td>
<td>0.002 ... 0.006</td>
<td>0.002 ... 0.006</td>
<td></td>
</tr>
<tr>
<td>100 ... 200</td>
<td>0.005 ... 0.010</td>
<td>0.005 ... 0.010</td>
<td></td>
</tr>
<tr>
<td>200 ... 300</td>
<td>0.010 ... 0.014</td>
<td>0.010 ... 0.014</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4

#### ISO 3 - Dimensions in mm

<table>
<thead>
<tr>
<th>d₁</th>
<th>Tolerance</th>
<th>( D_f )</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 ... 63</td>
<td>0.003</td>
<td>32 ... 63</td>
<td>0.012</td>
</tr>
<tr>
<td>30 ... 125</td>
<td>0.004</td>
<td>63 ... 125</td>
<td>0.016</td>
</tr>
<tr>
<td>125 ... 250</td>
<td>0.020</td>
<td>125 ... 250</td>
<td>0.020</td>
</tr>
</tbody>
</table>

### Table 5

#### ISO 5 - Dimensions in mm

<table>
<thead>
<tr>
<th>d₁</th>
<th>Tolerance</th>
<th>( D_f )</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 ... 63</td>
<td>0.005</td>
<td>32 ... 63</td>
<td>0.020</td>
</tr>
<tr>
<td>63 ... 125</td>
<td>0.006</td>
<td>63 ... 125</td>
<td>0.025</td>
</tr>
<tr>
<td>125 ... 250</td>
<td>0.032</td>
<td>125 ... 250</td>
<td>0.032</td>
</tr>
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</table>
**ISO 7 - Dimensions in mm**

### Table 6

<table>
<thead>
<tr>
<th>d₁</th>
<th>L₀</th>
<th>Tolerance</th>
<th>d₁</th>
<th>L₀</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 ... 50</td>
<td>50 ... 300</td>
<td>0,020 ... 0,120</td>
<td>t = ( \frac{L₀ \times 0,050}{125} )</td>
<td>25 ... 50</td>
<td>50 ... 100</td>
</tr>
<tr>
<td></td>
<td>300 ... 500</td>
<td>0,120 ... 0,200</td>
<td></td>
<td>100 ... 200</td>
<td>0,012 ... 0,025</td>
</tr>
<tr>
<td></td>
<td>500 ... 1000</td>
<td>0,200 ... 0,400</td>
<td></td>
<td>200 ... 300</td>
<td>0,025 ... 0,038</td>
</tr>
<tr>
<td>63 ... 125</td>
<td>125 ... 300</td>
<td>0,040 ... 0,094</td>
<td>t = ( \frac{L₀ \times 0,063}{200} )</td>
<td>63 ... 125</td>
<td>50 ... 100</td>
</tr>
<tr>
<td></td>
<td>300 ... 500</td>
<td>0,094 ... 0,157</td>
<td></td>
<td>100 ... 200</td>
<td>0,010 ... 0,020</td>
</tr>
<tr>
<td></td>
<td>500 ... 1000</td>
<td>0,157 ... 0,315</td>
<td></td>
<td>200 ... 300</td>
<td>0,020 ... 0,030</td>
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</tbody>
</table>

### Table 7

**Radial run-out of the free ends with rigidly blocked nut**

<table>
<thead>
<tr>
<th>d₁</th>
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<th>D₁</th>
<th>Tolerance</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 ... 63</td>
<td>0,006</td>
<td>32 ... 63</td>
<td>0,025</td>
<td>0,025</td>
</tr>
<tr>
<td>80 ... 125</td>
<td>0,008</td>
<td>63 ... 125</td>
<td>0,032</td>
<td>0,032</td>
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<tr>
<td></td>
<td></td>
<td>125 ... 250</td>
<td>0,040</td>
<td>0,040</td>
</tr>
</tbody>
</table>

**For ISO**

<table>
<thead>
<tr>
<th>d₁</th>
<th>L₀</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25 ... 50</td>
<td>50 ... 300</td>
</tr>
<tr>
<td>1</td>
<td>63 ... 125</td>
<td>100 ... 600</td>
</tr>
<tr>
<td>3</td>
<td>25 ... 50</td>
<td>50 ... 300</td>
</tr>
<tr>
<td>3</td>
<td>63 ... 125</td>
<td>100 ... 600</td>
</tr>
<tr>
<td>5</td>
<td>25 ... 50</td>
<td>50 ... 300</td>
</tr>
<tr>
<td>5</td>
<td>63 ... 125</td>
<td>100 ... 600</td>
</tr>
</tbody>
</table>
### Geometric profile of the track.ball area

Ball/track contact pressures and, therefore, axial load capacity are optimized through in-depth study of the profile of the groove consisting of two gothic arcs that are in a specific ratio to the radius of the ball $D_w/2$, so as to generate the optimal contact angle $\alpha$ (➔ fig. 5).

According to the direction of the load, the ball/track contact points are at B or A. The displacement $\Delta a$ of the ball from point A to point B is the effective axial play of the ball screw. Under stationary conditions, the radial play $\Delta r$ of the system is related to this.

### Preload

Two nuts are used forced apart according to a preload force at rest $F_{pr}$ in order to enhance positioning accuracy, eliminating axial and radial play, and to improve system rigidity.

Application of an external load $F_A$ increases the load and deformation on nut 2 to the values $F(2)$ and $\Delta l_{b/t}(2)$ while nut 1 is detensioned to the same extent. When the external load reaches the value $F_{r} = 2.83 F_{pr}$, the preload is eliminated (condition of no play), (➔ diagram 1).

Figure 6 and diagram 2 show the different behaviour of nuts preloaded or with play. The optimal preload depends on a wide range of application parameters and must be “purpose-designed” for more harsher uses. SKF BSS recommends an optimal preload of maximum 12% of the basic dynamic axial load rating $C_{am}$.

Preload must be defined according to the load applied and the required rigidity. With external loads $F_A$, the preload value that...
ensures conditions of no play is, as seen above, equal to $F_d/2.83$.

Once the ball screw has been dimensioned with the calculated required rigidity, a further increase in the preload does not lead to any very noticeable increase in rigidity (Fig. 7) but tends to reduce ball screw life due to the increase in the operating torque and in temperature.

Each time the temperature increases by one degree above $20 \, ^\circ C$, there is an approx. $0.01 \, mm$ elongation per degree and per meter in the steel used to construct the precision ball screw.

Preloading systems

In addition to the above-mentioned system, in which two preloaded nuts are used, the single preloaded nut system can be applied by using larger-sized balls (with four contact points) or with a shift in the lead of the nut tracks.

Permissible deviations for the preload torque (ISO/DIS 3408-3 Draft Standard) Table 8 gives the maximum permissible tolerance values $\pm \Delta T_{pp}$ in % in relation to the nominal torque $T_{po}$; the effective values $T_{pa}$ and $\pm \Delta T_{pa}$ measured with the procedure outlined in the paragraph above must be within this range.

Materials and thermal expansions

SKF BSS ball screw shafts are made of particularly impurity-free steels, able to withstand the heat treatments applied without cracking or uncontrolled deformations.

The track-ball contact area is surface-hardened by applying strictly controlled induction hardening procedures for the screw shafts and casehardening procedures for the nuts followed by deep freeze treatment (for the residual austenite) and soft tempering. Constant hardening thicknesses of $\geq 2 \, mm$ are thus obtained with hardness values of $59 \, ... \, 62 \, HRC$.

The ends of the screws are usually hardened and tempered ($R = 80 \, ... \, 90 \, daN/mm^2$).

The thermal expansion coefficient of the screw is $K_a = 12 \times 10^{-6}/\text{degree}$; the resulting axial elongation at a thermal gradient of $\Delta \theta [^\circ C]$ is therefore:

$$\Delta l = K_a \Delta \theta \cdot L [\text{mm}]$$

This should be taken into account when selecting the correct preload and lead compensation in order to obtain optimal working conditions.

---

**Table 8**

<table>
<thead>
<tr>
<th>$T_{po}$ [Nm]</th>
<th>$L_u/d_0 &lt; 40; L_u &lt; 4000 , mm$</th>
<th>$\Delta T_{pp}$ (% of $T_{po}$)</th>
<th>$L_u/d_0 &lt; 60; L_u &lt; 4000 , mm$</th>
<th>$L_u &gt; 4000 , mm$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L_u/d_0 &lt; 40; L_u &lt; 4000 , mm$</td>
<td>$L_u/d_0 &lt; 60; L_u &lt; 4000 , mm$</td>
<td>$L_u &gt; 4000 , mm$</td>
<td></td>
</tr>
<tr>
<td>from to</td>
<td>ISO 1</td>
<td>ISO 3</td>
<td>ISO 5</td>
<td>ISO 7</td>
</tr>
<tr>
<td>0.2 to 0.4</td>
<td>35</td>
<td>40</td>
<td>50</td>
<td>–</td>
</tr>
<tr>
<td>0.4 to 0.6</td>
<td>25</td>
<td>40</td>
<td>40</td>
<td>–</td>
</tr>
<tr>
<td>0.6 to 1</td>
<td>25</td>
<td>30</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>1 to 2.5</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>2.5 to 6.3</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>6.3 to 10</td>
<td>–</td>
<td>15</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>
Checking of the maximum axial operating load

In low speed applications and generally speaking in all applications with high axial loads, $F_{\text{MAX}}$ greater than the mean load $F_m$, even for short periods, it is advisable to make a static check on possible permanent deformations generated at the ball/track contact. Referring to the definition of $C_{0a}$ and $C_{0am}$, the static load safety coefficient $f_s$ is calculated:

$$f_s = \frac{C_{0am}}{F_{\text{MAX}}}$$

which must be kept within the following values:

- $1 \ldots 1.5$ regular operation without vibrations
- $1.5 \ldots 2$ normal operation with limited vibrations
- $2 \ldots 3$ strong shock loads and vibrations
- $3 \ldots 4$ very smooth operating requirements

For compressive axial loads, this check must be made together with calculation of the maximum permissible column load.
Application of precision ball screw

**Lubrication**

**Oil**

Lubrication of precision ball screws has many similarities with lubrication of ball bearings, so that similar products are used. However, the conditions of accuracy in which ball screws must operate do not permit any noticeable increases in temperature; therefore, where the application allows, it is advisable to use oil lubrication which helps to disperse the heat in the track/ball contact area. Generally, the same oils are used as for ball bearings with optimal viscosity calculated according to the geometry, speed and operating temperature. The viscosity grade ISO VG [mm²/s or Cst at 40 °C] in conformity with DIN 51519 standard can be obtained from (→ Diagram 3) according to screw shaft diameter, average speed and operating temperature for the application concerned.

The amount of oil required also depends on the application conditions; an oil volume of 2 ... 5 cm³/h is usually prescribed for each ball turn (1 impulse every 5 ... 30 min). In case of oil-immersed horizontal screws, the level of lubricant must reach the axis of the lowest ball.

In case of applications with operating conditions other than normal, oils can be used with special additives to improve stability and anti-corrosion characteristics.

**Grease**

In low speed operating conditions, water-resistant greases are usually used according to grade 2 DIN 51825. Greasing should be repeated for machine tools every 2-3 months in the initial operating phase and 6 ... 10 months subsequently. The amount of grease used must fill approximately half of the available internal space. Greases with a different saponifying content must never be mixed. Under exceptional circumstances of use, such as high speed or heavy loads, it is advisable to use greases conforming to DIN 51818 prescriptions, type NLGI and NLGI 3. For specific lubrication SKF should be consulted for advices.

**Protective covers**

SKF BSS standard precision ball screws are supplied complete with plastic wiper rings which prevent leakage of lubricant and penetration of external impurities.

Special seals for applications in particularly dirty or contaminated environments can be designed case by case on request. A bellows or telescopic type protection is always useful in these cases.
Product information

Ordering key

Nut type:
- Nut with internal preload, DIN standard: PGFJ
- Double preloaded flanged nut: PGFL
- Double preloaded flanged nut, DIN: PGFE
- Cylindrical double preloaded nut: PGCL
- Nut with axial play: SGFL
- Nut with axial play, DIN: SGFE
- Cylindrical nut with axial play: SGCL
- Four contact preloaded flanged nut: QGFL
- Four contact preloaded flanged nut, DIN: QGFE
- Cylindrical four contact preloaded nut: QGCL

Nominal diameter × Lead [mm]

Hand:
- Right: R
- Left (on request): L

Number of circuits of balls

Threaded length / Total length [mm]

Lead precision:
- G5, G3, G1

Nut orientation:
Threaded side or flange of nut towards shorter (S) or longer (L) machined end of shaft.
In case of same end machining (–)

Machined end combination to customer’s drawing

Wipers:
- Always with wipers: WPR

Example: PGFE 32×5 R 5 330 / 445 G1 L HA +K WPR

Table 1

Axial static stiffness of the nut

Actual stiffness = theoretical stiffness × accuracy factor

<table>
<thead>
<tr>
<th>Accuracy factor*</th>
<th>0.6</th>
<th>0.55</th>
<th>0.5</th>
<th>0.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO Accuracy classes</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>

*Accuracy factor takes into account the effect on stiffness of dimensional errors, surface finish, nut/ball/screw shaft coupling during construction and assembly of the screw as a function of the ISO precision class.

Note:
In case L-HA+K of “Z” (to customer’s drawing) please, always send a readable DWG.
PGFJ - Flanged nut with internal preload, DIN standard

| Designation | Screw diameter \( d_0 \) | Lead \( P_h \) | Number of circuits of balls | Basic dynamic load ratings static \( C_a \) | Basic static load ratings \( C_{as} \) | Preload torque \( T_{pe} \) | Nut stiffness \( R_n \) | \( d_2 \) | \( D \) | \( J \) | Design \( D_5 \) | \( D_2 \) | \( A \) | \( A_3 \) | \( A_2 \) | \( L_8 \) |
|-------------|-----------------|--------|------------------|-------------|----------------|-----------------|----------------|--------|--------|--------|-------------|--------|-----|-----|-----|-----|-----|
| PGFJ 16 × 5 | 16 | 5 | 3 × 2 | 9,7 | 14,2 | 0,05 | 490 | 13,2 | 28 | 38 | 1 | 5,5 | 48 | 63 | 10 | 12 | 40 |
| PGFJ 20 × 5 | 20 | 5 | 3 × 2 | 13,4 | 24,5 | 0,08 | 780 | 17,2 | 36 | 47 | 1 | 6,6 | 58 | 65 | 10 | 12 | 44 |
| PGFJ 25 × 5 | 25 | 5 | 3 × 2 | 15,6 | 33,6 | 0,12 | 1 020 | 22,2 | 40 | 51 | 1 | 6,6 | 62 | 68 | 10 | 14 | 48 |
| PGFJ 25 × 10 | 25 | 10 | 3 × 2 | 20,2 | 39,5 | 0,16 | 980 | 21,6 | 40 | 51 | 1 | 6,6 | 62 | 104 | 10 | 15 | 48 |
| PGFJ 32 × 5 | 32 | 5 | 4 × 2 | 22,1 | 57 | 0,22 | 1 530 | 29,2 | 50 | 65 | 1 | 9 | 80 | 81 | 10 | 15 | 62 |
| PGFJ 32 × 10 | 32 | 10 | 3 × 2 | 42,2 | 80 | 0,43 | 1 300 | 26,7 | 50 | 65 | 1 | 9 | 80 | 117 | 16 | 18 | 62 |
| PGFJ 40 × 5 | 40 | 5 | 4 × 2 | 24,6 | 73 | 0,3 | 1 920 | 37,2 | 63 | 78 | 2 | 9 | 93 | 82 | 10 | 16 | 70 |
| PGFJ 40 × 10 | 40 | 10 | 4 × 2 | 59,6 | 130 | 0,75 | 1 860 | 34,7 | 63 | 78 | 2 | 9 | 93 | 142 | 16 | 18 | 70 |
| PGFJ 40 × 12 | 40 | 12 | 3 × 2 | 53,9 | 109 | 0,69 | 1 500 | 34,1 | 63 | 78 | 2 | 9 | 93 | 139 | 16 | 24 | 70 |
| PGFJ 40 × 20 | 40 | 20 | 3 × 2 | 46 | 98 | 0,59 | 1 470 | 34,7 | 63 | 78 | 2 | 9 | 93 | 200 | 25 | 30 | 70 |
| PGFJ 50 × 5 | 50 | 5 | 4 × 2 | 27,2 | 93 | 0,41 | 2 440 | 47,2 | 75 | 93 | 2 | 11 | 110 | 82 | 10 | 16 | 85 |
| PGFJ 50 × 10 | 50 | 10 | 4 × 2 | 68 | 170 | 1,06 | 2 420 | 44,7 | 75 | 93 | 2 | 11 | 110 | 144 | 16 | 20 | 85 |
| PGFJ 50 × 12 | 50 | 12 | 3 × 2 | 62,8 | 147 | 0,99 | 1 700 | 44,1 | 75 | 93 | 2 | 11 | 110 | 139 | 16 | 24 | 85 |
| PGFJ 50 × 20 | 50 | 20 | 3 × 2 | 62,5 | 147 | 1 | 1 770 | 44,1 | 75 | 93 | 2 | 11 | 110 | 200 | 25 | 30 | 85 |
| PGFJ 63 × 5 | 63 | 5 | 4 × 2 | 30 | 120 | 0,58 | 2 800 | 60,2 | 90 | 108 | 2 | 11 | 125 | 84 | 10 | 18 | 95 |
| PGFJ 63 × 10 | 63 | 10 | 4 × 2 | 77,5 | 227 | 1,51 | 2 920 | 57,7 | 90 | 108 | 2 | 11 | 125 | 147 | 16 | 22 | 95 |
| PGFJ 63 × 12 | 63 | 12 | 3 × 2 | 89 | 248 | 1,75 | 2 910 | 57,1 | 95 | 115 | 2 | 13,5 | 135 | 148 | 25 | 32 | 100 |
| PGFJ 63 × 20 | 63 | 20 | 3 × 2 | 99 | 234 | 1,98 | 2 200 | 55 | 95 | 115 | 2 | 13,5 | 135 | 224 | 25 | 32 | 100 |
| PGFJ 80 × 10 | 80 | 10 | 4 × 2 | 86 | 293 | 2,12 | 3 690 | 74,7 | 105 | 125 | 2 | 13,5 | 145 | 150 | 16 | 24 | 110 |
| PGFJ 80 × 20 | 80 | 20 | 3 × 2 | 162 | 393 | 4,12 | 3 050 | 69,7 | 125 | 145 | 2 | 13,5 | 165 | 224 | 25 | 32 | 130 |

* See table 1 page 22

Options: – Balls in ceramic material
– Rotating nut
PGFL - Double preloaded flanged nut long lead

<table>
<thead>
<tr>
<th>Designation</th>
<th>Screw diameter $d_0$</th>
<th>Lead $P_h$</th>
<th>Number of circuits of balls</th>
<th>Basic load ratings static $C_a$, $C_{as}$</th>
<th>Preload torque $T_{pp}$</th>
<th>Nut stiffness $R_n$</th>
<th>$d_2$</th>
<th>$D$</th>
<th>$D_5$</th>
<th>$D_4$</th>
<th>$A_{dbl}$ nut</th>
<th>$A_3$ Sgle nut</th>
<th>$A_2$</th>
<th>$A_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGFL 25×20</td>
<td>25</td>
<td>20</td>
<td>2,75</td>
<td>20,5, 43</td>
<td>0,20</td>
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<td>47</td>
<td>58</td>
<td>6,5</td>
<td>73</td>
<td>178</td>
<td>89</td>
<td>25</td>
</tr>
<tr>
<td>PGFL 25×25</td>
<td>25</td>
<td>25</td>
<td>2,75</td>
<td>20,5, 43</td>
<td>0,20</td>
<td>980</td>
<td>21,6</td>
<td>47</td>
<td>58</td>
<td>6,5</td>
<td>73</td>
<td>178</td>
<td>89</td>
<td>25</td>
</tr>
<tr>
<td>PGFL 32×20*</td>
<td>32</td>
<td>20</td>
<td>2,75</td>
<td>30, 60</td>
<td>0,3</td>
<td>900</td>
<td>25</td>
<td>55</td>
<td>70</td>
<td>8,5</td>
<td>88</td>
<td>176</td>
<td>86</td>
<td>25</td>
</tr>
<tr>
<td>PGFL 32×25*</td>
<td>32</td>
<td>25</td>
<td>2,75</td>
<td>29, 60</td>
<td>0,36</td>
<td>900</td>
<td>25</td>
<td>55</td>
<td>70</td>
<td>8,5</td>
<td>88</td>
<td>206</td>
<td>97</td>
<td>25</td>
</tr>
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<td>32</td>
<td>1,75</td>
<td>19,5, 41,8</td>
<td>0,19, 60</td>
<td>0,19</td>
<td>600</td>
<td>25</td>
<td>55</td>
<td>70</td>
<td>8,5</td>
<td>88</td>
<td>196</td>
<td>91</td>
<td>25</td>
</tr>
<tr>
<td>PGFL 40×40</td>
<td>40</td>
<td>40</td>
<td>1,75</td>
<td>30,9, 68,4</td>
<td>0,42</td>
<td>900</td>
<td>32</td>
<td>84</td>
<td>104</td>
<td>10,5</td>
<td>126</td>
<td>210</td>
<td>110</td>
<td>25</td>
</tr>
<tr>
<td>PGFL 50×50</td>
<td>50</td>
<td>50</td>
<td>1,8</td>
<td>36,5, 72,8</td>
<td>0,3</td>
<td>1 220</td>
<td>42</td>
<td>90</td>
<td>114</td>
<td>10,5</td>
<td>135</td>
<td>280</td>
<td>130</td>
<td>25</td>
</tr>
<tr>
<td>PGFL 63×50</td>
<td>63</td>
<td>50</td>
<td>1,8</td>
<td>40, 114</td>
<td>0,4</td>
<td>1 500</td>
<td>55</td>
<td>100</td>
<td>124</td>
<td>13</td>
<td>147</td>
<td>284</td>
<td>154</td>
<td>25</td>
</tr>
</tbody>
</table>

* Brush wipers & n × $d_0 < 70 000$

** See table 1 page 22

Note: Nut is available with axial play "SGFL", nut length will be $A_y$ or with contact points preload "QGFL".

Options: – Balls in ceramic material
– Rotating nut
PGFE - Double preloaded flanged nut, DIN

<table>
<thead>
<tr>
<th>Designation</th>
<th>Screw diameter d₀</th>
<th>Lead pₙ</th>
<th>Num. of circuits balls</th>
<th>Basic load ratings dynamic C₂₀</th>
<th>Preload torque Tₚₑ</th>
<th>Nut stiffness R₁₀⁻¹</th>
<th>d₂</th>
<th>D</th>
<th>J</th>
<th>Design D₅</th>
<th>D₄</th>
<th>A</th>
<th>Dble nut</th>
<th>As Sgle nut</th>
<th>A₃</th>
<th>A₂</th>
<th>Lₐ</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGFE 16×5</td>
<td>16</td>
<td>5</td>
<td>3</td>
<td>9.7</td>
<td>0.05</td>
<td>490</td>
<td>13.2</td>
<td>28</td>
<td>38</td>
<td>1</td>
<td>5.5</td>
<td>48</td>
<td>79</td>
<td>45.5</td>
<td>10</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td>PGFE 20×5</td>
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<td>5</td>
<td>3</td>
<td>13.4</td>
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<td>780</td>
<td>17.2</td>
<td>36</td>
<td>47</td>
<td>1</td>
<td>6.6</td>
<td>58</td>
<td>79</td>
<td>45.5</td>
<td>10</td>
<td>12</td>
<td>44</td>
</tr>
<tr>
<td>PGFE 25×2</td>
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** See table 1 page 22

** Note:**
Nut is available with axial play “SGFE”, nut length will be Aₙ or with contact points preload “QGFE”.

** Options:**
- Balls in ceramic material
- Rotating nut
### Designation

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### Options

- Balls in ceramic material
- Rotating nut

Note:

Nutm is available with axial play "SGFE", nut length will be $A_s$ or with contact points preload "QGFE".

* See table 1 page 22
### PGFE (Continued)

![Diagram of PGFE designations and options]

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* See table 1 page 22

**Note:**
Nut is available with axial play “SGFE”, nut length will be $A_5$ or with contact points preload “QGFE”.

**Options:**
- Balls in ceramic material
- Rotating nut
### PGCL - Cylindrical double preloaded nut

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*See table 1 page 22

**Note:**
Nut is available with axial play "SGCL", nut length will be A₂ or with contact points preload "QGCL".

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- Rotating nut
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<td>393</td>
<td>4.12</td>
<td>3 050</td>
<td>69.7</td>
<td>125</td>
<td>8×4×40</td>
<td>270</td>
<td>145</td>
</tr>
<tr>
<td>PGCL 80×20</td>
<td>80</td>
<td>20</td>
<td>4</td>
<td>207</td>
<td>524</td>
<td>5.26</td>
<td>4 200</td>
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<td>8×4×40</td>
<td>310</td>
<td>165</td>
</tr>
<tr>
<td>PGCL 80×40</td>
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<td>40</td>
<td>3</td>
<td>162</td>
<td>393</td>
<td>4.19</td>
<td>3 050</td>
<td>69.7</td>
<td>125</td>
<td>8×4×40</td>
<td>410</td>
<td>224</td>
</tr>
<tr>
<td>PGCL 100×10</td>
<td>100</td>
<td>10</td>
<td>4</td>
<td>100</td>
<td>372</td>
<td>3.06</td>
<td>4 090</td>
<td>94.7</td>
<td>125</td>
<td>10×5×32</td>
<td>158</td>
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</tr>
<tr>
<td>PGCL 100×10</td>
<td>100</td>
<td>10</td>
<td>6</td>
<td>142</td>
<td>558</td>
<td>4.35</td>
<td>6 200</td>
<td>94.7</td>
<td>125</td>
<td>10×5×40</td>
<td>198</td>
<td>104</td>
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<td>12</td>
<td>4</td>
<td>112</td>
<td>425</td>
<td>3.4</td>
<td>4 300</td>
<td>94.1</td>
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<td>99</td>
</tr>
<tr>
<td>PGCL 100×12</td>
<td>100</td>
<td>12</td>
<td>6</td>
<td>158</td>
<td>633</td>
<td>4.8</td>
<td>6 000</td>
<td>94.1</td>
<td>135</td>
<td>10×5×40</td>
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<td>123</td>
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<tr>
<td>PGCL 100×16</td>
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<td>16</td>
<td>4</td>
<td>162</td>
<td>532</td>
<td>5.02</td>
<td>4 400</td>
<td>92</td>
<td>135</td>
<td>10×5×40</td>
<td>248</td>
<td>132</td>
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<tr>
<td>PGCL 100×20</td>
<td>100</td>
<td>20</td>
<td>3</td>
<td>184</td>
<td>514</td>
<td>5.78</td>
<td>3 650</td>
<td>89.7</td>
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<td>235</td>
<td>685</td>
<td>7.38</td>
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<td>89.7</td>
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<td>10×5×40</td>
<td>310</td>
<td>165</td>
</tr>
<tr>
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<td>100</td>
<td>40</td>
<td>3</td>
<td>177.5</td>
<td>491</td>
<td>5.64</td>
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<td>89.7</td>
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<td>125</td>
<td>12</td>
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<td>96</td>
<td>402</td>
<td>3.67</td>
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<tr>
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<td>12</td>
<td>6</td>
<td>174</td>
<td>803</td>
<td>6.65</td>
<td>7 000</td>
<td>119.1</td>
<td>165</td>
<td>10×5×40</td>
<td>234</td>
<td>123</td>
</tr>
<tr>
<td>PGCL 125×16</td>
<td>125</td>
<td>16</td>
<td>4</td>
<td>182</td>
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<td>7</td>
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<td>132</td>
</tr>
<tr>
<td>PGCL 125×20</td>
<td>125</td>
<td>20</td>
<td>3</td>
<td>210</td>
<td>684</td>
<td>8.16</td>
<td>4 830</td>
<td>114.7</td>
<td>170</td>
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<td>270</td>
<td>145</td>
</tr>
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<td>125</td>
<td>20</td>
<td>4</td>
<td>269</td>
<td>910</td>
<td>10.45</td>
<td>6 100</td>
<td>114.7</td>
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<td>165</td>
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<td>40</td>
<td>3</td>
<td>207</td>
<td>671</td>
<td>8.11</td>
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<td>114.7</td>
<td>170</td>
<td>10×5×40</td>
<td>410</td>
<td>224</td>
</tr>
</tbody>
</table>

Options:  
- Balls in ceramic material  
- Rotating nut

* See table 1 page 22
Standard end machined

Standard end machining for nominal diameter ≥ 16 mm
Standard shaft ends for ball screws, nominal diameter ≥ 16 mm, have been developed to suit the SKF thrust bearings. These standard ends are the same for all screw types.

### Dimensions (mm)

<table>
<thead>
<tr>
<th>Size $d_0$</th>
<th>$d_5$</th>
<th>$d_6$</th>
<th>$d_{10}$</th>
<th>$d_{12}$</th>
<th>$d_{14}$</th>
<th>$B_1$</th>
<th>$B_2$</th>
<th>$B_3$</th>
<th>$B_7$</th>
<th>$B_9$</th>
<th>$d_8$</th>
<th>$G$</th>
<th>$G_1$</th>
<th>$m$</th>
<th>$d_6$</th>
<th>$c$</th>
<th>$c_1$</th>
<th>$b_2$</th>
<th>$d_7$</th>
<th>$r_a$</th>
<th>Keyway to DIN 6885</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>8 10</td>
<td>/ 10</td>
<td>8 53</td>
<td>16 13</td>
<td>69 10</td>
<td>29 2</td>
<td>0</td>
<td>12,5</td>
<td>M10×0,75</td>
<td>17</td>
<td>1,1</td>
<td>9,6</td>
<td>0,5</td>
<td>0,5</td>
<td>1,2</td>
<td>8,8</td>
<td>0,4</td>
<td>A2×2×12</td>
<td>A2×2×12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>10 12</td>
<td>/ 10</td>
<td>8 58</td>
<td>17 13</td>
<td>75 10</td>
<td>29 2</td>
<td>0</td>
<td>14,5</td>
<td>M12×1</td>
<td>18</td>
<td>1,1</td>
<td>9,6</td>
<td>0,5</td>
<td>0,5</td>
<td>1,5</td>
<td>10,5</td>
<td>0,8</td>
<td>A3×3×12</td>
<td>A2×2×12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>15 17</td>
<td>/ 17</td>
<td>15 66</td>
<td>30 16</td>
<td>96 13</td>
<td>46 4,5</td>
<td>0</td>
<td>20</td>
<td>M17×1</td>
<td>22</td>
<td>1,1</td>
<td>16,2</td>
<td>0,5</td>
<td>0,5</td>
<td>1,5</td>
<td>15,5</td>
<td>0,8</td>
<td>A5×5×25</td>
<td>A5×5×25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>17 20</td>
<td>/ 17</td>
<td>15 69</td>
<td>30 16</td>
<td>99 13</td>
<td>46 4,5</td>
<td>0</td>
<td>21,7</td>
<td>M20×1</td>
<td>22</td>
<td>1,1</td>
<td>16,2</td>
<td>0,5</td>
<td>0,5</td>
<td>1,5</td>
<td>18,5</td>
<td>0,8</td>
<td>A5×5×25</td>
<td>A5×5×25</td>
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<td></td>
</tr>
<tr>
<td>40</td>
<td>25 30</td>
<td>/ 30</td>
<td>25 76</td>
<td>45 22</td>
<td>121 17,5</td>
<td>67 4,5</td>
<td>0</td>
<td>33,5</td>
<td>M30×1,5</td>
<td>25</td>
<td>1,6</td>
<td>28,6</td>
<td>1</td>
<td>0,5</td>
<td>2,3</td>
<td>27,8</td>
<td>0,8</td>
<td>A8×7×40</td>
<td>A8×7×40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>30 35</td>
<td>/ 30</td>
<td>25 84</td>
<td>55 22</td>
<td>139 17,5</td>
<td>67 4,5</td>
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<td>35,5</td>
<td>M35×1,5</td>
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<td>1,6</td>
<td>28,6</td>
<td>1</td>
<td>0,5</td>
<td>2,3</td>
<td>32,8</td>
<td>1,2</td>
<td>A8×7×45</td>
<td>A8×7×45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>40 50</td>
<td>/ 45</td>
<td>40 114</td>
<td>65 28</td>
<td>179 20,75</td>
<td>93 3</td>
<td>0</td>
<td>54</td>
<td>M50×1,5</td>
<td>32</td>
<td>1,85</td>
<td>42,5</td>
<td>1,5</td>
<td>1</td>
<td>2,3</td>
<td>47,8</td>
<td>1,2</td>
<td>A12×8×50</td>
<td>A12×8×50</td>
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<td></td>
</tr>
<tr>
<td>80</td>
<td>50 55</td>
<td>/ 45</td>
<td>40 119</td>
<td>75 28</td>
<td>194 20,75</td>
<td>93 3</td>
<td>0</td>
<td>54</td>
<td>M55×2</td>
<td>32</td>
<td>1,85</td>
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<td>1,5</td>
<td>1</td>
<td>3</td>
<td>52,1</td>
<td>1,6</td>
<td>A14×9×63</td>
<td>A12×8×50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) For screw $d_0$ 16 to $d_0$ 32; 2) For screw $d_0$ 40 to $d_0$ 63; 3) For ends 4A or 5A; 0 No shoulder; / No shoulder

### Shaft end combinations

<table>
<thead>
<tr>
<th>Ø ≥ 16 mm</th>
<th>Order code</th>
<th>Two machined ends</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA (without length indication)</td>
<td>cut only</td>
<td></td>
</tr>
<tr>
<td>BA</td>
<td>1A + 2A</td>
<td></td>
</tr>
<tr>
<td>FA*</td>
<td>2A + 2A</td>
<td></td>
</tr>
<tr>
<td>GA*</td>
<td>2A + 3A</td>
<td></td>
</tr>
<tr>
<td>HA</td>
<td>2A + 4A</td>
<td></td>
</tr>
<tr>
<td>JA</td>
<td>2A + 5A</td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td>3A + 5A</td>
<td></td>
</tr>
<tr>
<td>SA (+ length)</td>
<td>Ends to root diameter $d_2$, any possible lengths.</td>
<td></td>
</tr>
<tr>
<td>UA* (+ length)</td>
<td>End machined to diameter $d_3$ under induction hardening, any possible lengths.</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Keyway</td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>To customer’s drawing</td>
<td></td>
</tr>
</tbody>
</table>

* Attention! This mounting requires the greatest precautions. Please contact us.
Standard machined ends for nominal diameter ≥ 16 mm
Threaded length = total length - end length

End bearings

A special design for a specific application
High-precision Single Direction Angular Contact Thrust Ball Bearings have been developed especially for the support of ball and roller screws in machine tools. They incorporate a large number of balls and have a special internal design with a contact angle of 60° to provide superior axial stiffness. These bearings also have high axial load ratings, high running accuracy together with speed and acceleration capability and low frictional torque.

Ready to mount units
To simplify and speed up mounting, complete greased-for-life cartridge units are available in matched sets of two, three or four Single Direction Angular Contact Thrust Ball Bearings in a flanged housing. These units are sealed and due to the flange can be simply bolted to the machine frame.

Double Direction Angular Contact Thrust Ball Bearings with and without integrated flange, sealed and greased for life are also a part of the product range.

Note:
For other informations on the products please consult SKF BSS.
Final certification of standard testing
The certificate of conformity gives the geometric parameters measured and compared with SKF BSS specifications as set forth on pages above.

The radial run-out of the free ends of the screw with the ball nut rigidly fixed can also be certified.

Final certification of special inspection
provided on request
a Measuring and plotting of the dynamic preload drag torque according to ISO/DIS 3408-3 specifications or according to special customer requests (➔ fig. 1).
b Measuring and plotting of actual travel variation compared with permissible value, using computer controlled laser systems (➔ fig. 2).

c Measuring and plotting of nut axial rigidity according to ISO/DIS 3408-3 specifications (➔ fig. 3).
d The very low speed rotation torque can be measured and plotted, if specifically requested, in order to assess the "stick-slip" of the ball screw.
### BALL SCREWS
#### RIGIDITY CERTIFICATE
##### ACCURACY CLASS ISO 3

<table>
<thead>
<tr>
<th>SKF BSS</th>
<th>Screw Diameter</th>
<th>Lead</th>
<th>Ball Diameter</th>
<th>Required Rigidity</th>
<th>PRODUCT INSPECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TORINO - ITALY</td>
<td>40 mm</td>
<td>5 mm</td>
<td>3,5 mm</td>
<td>90/100 daN/μm</td>
<td></td>
</tr>
</tbody>
</table>

Preload $F_{pr} = 100$ daN

$F_1 = 0.5 \times F_{pr} = 50$ daN

$F_2 = 2 \times F_{pr} = 200$ daN

$\Delta \lambda_1 = -1.004 \mu$m

$\Delta \lambda_2 = -3.889 \mu$m

are the sum of the elastic deformations in the two directions caused respectively by the axial loads $\pm F_1 = \pm F_2$

Rigidity in the range $\pm F_1$

$R_{ext} = \frac{2F_1}{\Delta \lambda_1} = 99.6$ daN/μm

Rigidity in the range $+F_1$ to $+F_2$ and $-F_1$ to $-F_2$

$R_{ext} = \frac{2(F_2 - F_1)}{\Delta \lambda_2 - \Delta \lambda_1} = 104.0$ daN/μm

### BALL SCREWS
#### TRAVEL DEVIATION PLOT
##### ACCURACY CLASS ISO 3

<table>
<thead>
<tr>
<th>SKF BSS</th>
<th>Screw Diameter</th>
<th>Lead</th>
<th>Ball Diameter</th>
<th>Useful travel</th>
<th>Thread length</th>
<th>PRODUCT INSPECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TORINO - ITALY</td>
<td>40 mm</td>
<td>5 mm</td>
<td>3,175 mm</td>
<td>600 mm</td>
<td>685 mm</td>
<td></td>
</tr>
</tbody>
</table>

RUN | TARGET | ERROR
---|--------|--------
1 | +0.000000 | +0.001000
1 | +100,000000 | -0.004000
1 | +200,000000 | -0.003000
1 | +300,000000 | -0.003000
1 | +400,000000 | +0.000000
1 | +500,000000 | +0.000000
1 | +600,000000 | -0.001000

Travel deviation [mm]
This catalogue concerns only ground ball screws. However, a ground ball screw may not meet all the demands of your application; in this case choose a roller screw as roller screws perform beyond the limits of ball screws.

How to orientate your choice

In our wide range, you are sure to find the product which fits exactly your requirements:

- The miniature ball screws (➔ fig. 1), either with ball recirculation by integrated tube or with inserts, are very compact. Backdriving makes them highly efficient.
- The rolled screws (➔ fig. 2) enable you to select the right level of requirement: simple transport screws, very fast screws with long lead, or preloaded screws for more precision.
- Ground ball screws for more rigidity and precision (➔ fig. 3).
- High load capacity ball screws with BIG BALLS (➔ fig. 4) for moulding injection, punching, bending press machines and direct hydraulic cylinder replacements.
- Roller screws (➔ fig. 5) which are far beyond the limits of any ball screws as for heavy loads, ultimate precision and rigidity, high speed and acceleration and very difficult environments.

Table 1 will guide you in your first approach.
<table>
<thead>
<tr>
<th>Type</th>
<th>Details</th>
<th>Basic dynamic load rating</th>
<th>Precision Ep ((\mu)) on 300 mm</th>
<th>High duty cycles</th>
<th>Adverse environment (Spec. steel, pollution)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SH series</strong></td>
<td>Diameter: Ø 6 to 16 mm</td>
<td>Up to 5.2 kN</td>
<td>G9 (130 (\mu)) to G5 (23 (\mu))</td>
<td></td>
<td>good</td>
</tr>
<tr>
<td><strong>SX, SL/TL, SN/TN/PN</strong></td>
<td>Diameter: Ø 16 to 63 mm</td>
<td>Up to 80 kN</td>
<td>G9 (130 (\mu)) to G5 (23 (\mu))</td>
<td></td>
<td>satisfactory</td>
</tr>
<tr>
<td><strong>PGFJ, PGFL, PGFE, PGCL</strong></td>
<td>Diameter: Ø 16 to 125 mm</td>
<td>Up to 270 kN</td>
<td>G5 (23 (\mu)) to G1 (6 (\mu))</td>
<td></td>
<td>satisfactory</td>
</tr>
<tr>
<td><strong>SGFH</strong></td>
<td>Diameter: Ø 50 to 125 mm</td>
<td>Up to 850 kN</td>
<td>G5 (23 (\mu)) to G1 (6 (\mu))</td>
<td></td>
<td>exceptional</td>
</tr>
<tr>
<td><strong>SRC, SRF, TRK/PRK, SVC, PVK</strong></td>
<td>Diameter: Ø 8 to 210 mm</td>
<td>Up to 2235 kN</td>
<td>G5 (23 (\mu)) to G1 (6 (\mu))</td>
<td></td>
<td>exceptional</td>
</tr>
</tbody>
</table>
4 Product information
Calculation formulas

1 Dynamic load rating (N) and Basic life rating

\[ L_{10} = \left( \frac{C_a}{F_m} \right)^{3} \quad \text{or} \quad C_{req} = F_m (L_{10})^{1/3} \]

\( L_{10} \) = life (million of revolutions)
\( C_a \) = basic dynamic load rating
\( C_{req} \) = required dynamic load rating
\( F_m \) = cubic mean load [N]

2 Cubic mean load (N)

\[ F_m = \frac{F_1 L_1 + F_2 L_2 + F_3 L_3 + \ldots}{(L_1 + L_2 + L_3 + \ldots)^{1/3}} \]

\[ F_m = \frac{F_{\min} + 2F_{\max}}{(L_1 + L_2 + L_3 + \ldots)^{1/3}} \]

\( F_m \) = cubic mean load [N]
\( L_{10} \) = life (million of revolutions)
\( C_a \) = basic dynamic load rating
\( C_{req} \) = required dynamic load rating
\( F_m \) = cubic mean load [N]

3 Critical speed of screw shaft (rpm) (no safety factor)

\( n_{cr} = 490 \cdot 10^4 f_1 d_2^2 \]

\( d_2 \) = root diameter [mm]
\( \ell \) = free length, or distance between the two support bearings

\( f_1 = 0.9 \) fixed, free
\( f_1 = 3.8 \) fixed, supported
\( f_1 = 5.6 \) fixed, fixed

4 Speed limit of the mechanism

\( n = \text{revolutions per minute} \)
\( d_0 = \text{screw shaft nominal diameter} \)

For instance: \( n \times d_0 < 110,000 \), to the exception of long leads:
32 × 20/25/32 − 40 × 40 − 50 × 50
and 63 × 50: \( n \times d_0 < 70,000 \), if higher, please consult SKF

5 Buckling strength (N)

\( F_c = \frac{34,000 \cdot f_2 \cdot d_2^6}{\ell^2} \)

\( d_2 \) = root diameter [mm]
\( \ell \) = free length, or distance between the two support bearings

\( f_2 = \text{mounting correction factor} \)

\( f_2 = 0.25 \) fixed, free A
\( f_2 = 1 \) supported, supported B
\( f_2 = 2 \) fixed, supported C
\( f_2 = 4 \) fixed, fixed D
6 Deflection of the screw shaft due to its own weight (mm)

\[ \Delta l_{\text{rad}} = K_p \cdot \frac{P \cdot l^4}{E \cdot I} \]

\( E = 21\,000 \, [\text{daN/mm}^2] \)
\( l = \frac{\Pi}{64} \cdot d^3 \, [\text{mm}^4] \)

\( \Delta l_{\text{rad}} = \begin{cases} 
1/8 & \text{in configuration A (fixed/free) } Dl_{\text{rad}} \text{ on the free end} \\
5/384 & \text{in configuration B (supported/supported) } Dl_{\text{rad}} \text{ on the centreline} \\
1/185 & \text{in configuration C (fixed/supported) } Dl_{\text{rad}} \text{ at } 0.42 \cdot L \text{ from the simple support} \\
1/384 & \text{in configuration D (fixed/free) } Dl_{\text{rad}} \text{ on the centreline} 
\end{cases} \)

Intermediate supports that reduce the above deflection can be used in very long applications.

7 Rigidity
The total rigidity of a screw is:

\[ \frac{1}{R_t} = \frac{1}{R_s} + \frac{1}{R_n} \]

The rigidity of a screw shaft is:
- Ball screw held rigidity at one end:

\[ R_s = 165 \, \frac{d_2^2 \, I}{I_2 \, (I - I_2)} \, [\text{N\mu m}] \]
for standard steel

- Ball screw held rigidity at both ends:

\[ R_s = \frac{165 \, d_2^2 \, I}{I_2 \, (I - I_2)} \, [\text{N\mu m}] \]
for standard steel

8 Theoretical efficiency
- direct \( (\eta) \)

\[ \eta = \frac{1}{1 + \frac{K \cdot d_0}{P_h}} \]

\( K = 0.00974 \)
\( d_0 = \text{nominal diameter of screw shaft} \)
\( P_h = \text{lead [mm]} \)

- indirect \( (\eta') \)

\[ \eta' = 2 - \frac{1}{\eta} \]

9 Practical efficiency \( (\eta_p) \)

\[ \eta_p = \eta \cdot 0.9 \]

The value 0.9 used is an average value between the practical efficiency of a new screw and that of a properly run-in screw. It should be used for industrial applications in all normal working conditions. For extreme cases, call us.
10 Input torque in a steady state (Nm)

\[ T = \frac{F \cdot P_h}{2000 \cdot \pi \cdot \eta_p} \]

\( F \) = maximum load of the cycle [N]

11 Power required in a steady state (W)

\[ P = \frac{F \cdot n \cdot P_h}{60000 \cdot \eta_p} \]

\( n \) = revolution per minute

12 Preload torque (Nm)

\[ T_{pr} = \frac{F_{pr} \cdot P_h}{1000 \cdot \pi} \left( \frac{1}{\eta} - 1 \right) \]

\( F_{pr} \) = preload force between a nut and the shaft [N]

13 Restraining torque (Nm)

(considering system backdriving)

\[ T_B = \frac{F \cdot P_h \cdot \eta'}{2000 \cdot \pi} \]

\( F \) = load [N]

For safety, we can use the theoretical indirect efficiency

14 Nominal motor torque when accelerating (Nm)

For a horizontal screw

\[ T_t = T_f + T_{pr} + \frac{P_h \cdot [F + m_L \cdot \mu_f \cdot g]}{2000 \cdot \pi \cdot \eta_p} + \omega \Sigma I \]

\( T_f \) = torque from friction in support bearings [Nm]
\( T_{pr} \) = preload torque [Nm]
\( \mu_f \) = coefficient of friction
\( \eta_p \) = real direct efficiency
\( \omega \) = angular acceleration [rad/s²]
\( m_L \) = mass of the load [kg]
\( g \) = acceleration of gravity: 9.8 [m/s²]
\( \Sigma I \) = \( I_M + I_L + I_S + I \cdot 10^{-9} \) [kg/m²]

For a vertical screw

\[ T_t = T_f + T_{pr} + \frac{P_h \cdot [F + m_L \cdot \mu_f \cdot g]}{2000 \cdot \pi \cdot \eta_p} + \omega \Sigma I \]

15 Nominal braking torque when decelerating (Nm)

For a horizontal screw

\[ T_t = T_f + T_{pr} + \frac{P_h \cdot \eta' \cdot [F + m_L \cdot \mu_f \cdot g]}{2000 \cdot \pi} + \omega \Sigma I \]

For a vertical screw

\[ T_t = T_f + T_{pr} + \frac{P_h \cdot \eta' \cdot [F + m_L \cdot \mu_f \cdot g]}{2000 \cdot \pi} + \omega \Sigma I \]

Note:
For additional information, please contact SKF.
### Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creq</td>
<td>Required load rating</td>
</tr>
<tr>
<td>Ca</td>
<td>kN The dynamic load rating ((L_{10})) is such that 90% of a sufficiently large sample of identical screws can be expected to attain or exceed 1 million revolutions under this constant centrally acting pure axial load without fatigue (flaking).</td>
</tr>
<tr>
<td>Cpa</td>
<td>kN The static load rating is that axial constant centrally acting load which produces a total permanent deformation of one raceway and roller of 0.0001 of the diameter of the curved surface of the roller.</td>
</tr>
<tr>
<td>F</td>
<td>N Axial load</td>
</tr>
<tr>
<td>Fc</td>
<td>N Compression load</td>
</tr>
<tr>
<td>Fm</td>
<td>N Constant mean axial load</td>
</tr>
<tr>
<td>Fr</td>
<td>N The preload force between a nut half (or nut) and the shaft</td>
</tr>
<tr>
<td>Fq</td>
<td>N The squeeze load applied to two nut halves (or nuts) by the housing or fixing bolts</td>
</tr>
<tr>
<td>Hv</td>
<td>- Vickers hardness</td>
</tr>
<tr>
<td>I</td>
<td>kgm² Inertia</td>
</tr>
<tr>
<td>I₁</td>
<td>kgm² Inertia of load</td>
</tr>
<tr>
<td>I₄</td>
<td>kgm² Inertia of motor</td>
</tr>
<tr>
<td>I₉nin</td>
<td>kgm² Inertia of nut when turning nut</td>
</tr>
<tr>
<td>I₉nin</td>
<td>kgm² Inertia of rollers when turning shaft</td>
</tr>
<tr>
<td>I₉np</td>
<td>kgm³/m Inertia of screw shaft per metre</td>
</tr>
<tr>
<td>L</td>
<td>(10^6) revs Life</td>
</tr>
<tr>
<td>L₁₀</td>
<td>(10^6) revs Basic life rating, millions of revolutions</td>
</tr>
<tr>
<td>L₁0h</td>
<td>hours Basic life rating, operating hours</td>
</tr>
<tr>
<td>M</td>
<td>(\mu)m Maximum difference between mean travels of screws in a matched set</td>
</tr>
<tr>
<td>N</td>
<td>- Number of thread starts on the screw shaft</td>
</tr>
<tr>
<td>Nₙ</td>
<td>- Standard number of rollers</td>
</tr>
<tr>
<td>Nₚₘₐₓ</td>
<td>- Maximum number of rollers</td>
</tr>
<tr>
<td>P</td>
<td>watts Power</td>
</tr>
<tr>
<td>Pₙ</td>
<td>mm Lead</td>
</tr>
<tr>
<td>R</td>
<td>N/(\mu)m Rigidity</td>
</tr>
<tr>
<td>Rₙn</td>
<td>N/(\mu)m Nut rigidity</td>
</tr>
<tr>
<td>Rₙg</td>
<td>N/(\mu)m Minimum guaranteed nut rigidity</td>
</tr>
<tr>
<td>Rₙₙ</td>
<td>N/(\mu)m Reference nut rigidity</td>
</tr>
<tr>
<td>Rₙₙp</td>
<td>N/(\mu)m Screw shaft rigidity</td>
</tr>
<tr>
<td>Rₙₚ</td>
<td>N/(\mu)m Total rigidity</td>
</tr>
<tr>
<td>T</td>
<td>Nm Torque</td>
</tr>
<tr>
<td>T₉</td>
<td>Nm Brake torque</td>
</tr>
<tr>
<td>T₉st</td>
<td>Nm Total torque at constant speed</td>
</tr>
<tr>
<td>T₉f</td>
<td>Nm Torque from friction in support bearings, motor, seals, etc</td>
</tr>
<tr>
<td>T₉be</td>
<td>Nm Torque for play elimination</td>
</tr>
<tr>
<td>T₉pr</td>
<td>Nm Preload torque</td>
</tr>
<tr>
<td>T₉st</td>
<td>Nm Starting torque</td>
</tr>
<tr>
<td>T₉t</td>
<td>Nm Total torque</td>
</tr>
<tr>
<td>U</td>
<td>mm Stroke length</td>
</tr>
<tr>
<td>V</td>
<td>hr⁻¹ Strokes per hour</td>
</tr>
<tr>
<td>W</td>
<td>hr/day Hours per day</td>
</tr>
<tr>
<td>X</td>
<td>days/year Days per year</td>
</tr>
<tr>
<td>Y</td>
<td>years</td>
</tr>
<tr>
<td>Zₙ</td>
<td>cc Grease quantity for screw shaft</td>
</tr>
<tr>
<td>Zₙn</td>
<td>cc Grease quantity for nut</td>
</tr>
<tr>
<td>c</td>
<td>(\mu)m Travel compensation - the difference between the specified travel and the nominal travel. Its value is always defined by the customer: if not specified it will be assumed to be zero. (The specified travel can also be defined by the specified lead multiplied by the number of revolutions)</td>
</tr>
<tr>
<td>d₀</td>
<td>mm Nominal diameter of screw shaft</td>
</tr>
<tr>
<td>d₁</td>
<td>mm Root diameter</td>
</tr>
<tr>
<td>d₂</td>
<td>mm Bore</td>
</tr>
<tr>
<td>eₚ</td>
<td>(\mu)m Tolerance of actual mean travel, (l_m) relative to specified travel (l_s)</td>
</tr>
<tr>
<td>f</td>
<td>- Factors</td>
</tr>
<tr>
<td>g</td>
<td>m/s² Acceleration of gravity: 9.8</td>
</tr>
<tr>
<td>l</td>
<td>mm Length</td>
</tr>
<tr>
<td>lₙ</td>
<td>mm Nominal travel - the nominal lead multiplied by the number of revolutions</td>
</tr>
<tr>
<td>lₙ₁</td>
<td>mm Threaded length</td>
</tr>
<tr>
<td>lₙ₂</td>
<td>mm Excess travel - at each end of the threaded length a distance (l_e) is subtracted to leave (l_s) the useful travel. The specified lead precision does not apply to the lengths (l_e), (l_s = l_1 - 2 l_e)</td>
</tr>
<tr>
<td>lₙ₃</td>
<td>mm Actual mean travel. The curve is the result of measurements at 20 °C of the screw shaft, (l_m) is the line which fits the curve by the method of least squares Specified travel</td>
</tr>
<tr>
<td>lₙ₅</td>
<td>mm Maximum total length</td>
</tr>
<tr>
<td>lₙ₆</td>
<td>mm Useful travel - the length of thread which is subject to the specified lead precision</td>
</tr>
<tr>
<td>m</td>
<td>kg Mass</td>
</tr>
<tr>
<td>mₙₙ</td>
<td>kg Mass of the nut</td>
</tr>
<tr>
<td>mₙₕ</td>
<td>kg Mass of the screw shaft per metre</td>
</tr>
<tr>
<td>n</td>
<td>rpm Rotational speed</td>
</tr>
<tr>
<td>nₙcₙ</td>
<td>rpm Critical speed</td>
</tr>
<tr>
<td>nₙₚ</td>
<td>rpm Maximum permissible speed</td>
</tr>
<tr>
<td>sₚₚ</td>
<td>mm Maximum axial play</td>
</tr>
<tr>
<td>t</td>
<td>(\mu)m Manufacturing tolerance</td>
</tr>
<tr>
<td>v</td>
<td>(\mu)m Travel variation - the band width or the distance between the two straight lines parallel to the actual mean travel which enclose the curve</td>
</tr>
<tr>
<td>v₃₃₀</td>
<td>(\mu)m The bandwidth over any 300 mm section of the useful travel. (v_{300a}) and (v_{300p}) are actual and permissible values</td>
</tr>
<tr>
<td>vₙₙ</td>
<td>(\mu)m The bandwidth over the useful travel. (v_{1a}) and (v_{1p}) are actual and permissible values</td>
</tr>
<tr>
<td>δ</td>
<td>(\mu)m Helix angle of the screw shaft thread</td>
</tr>
<tr>
<td>λ</td>
<td>° Friction angle</td>
</tr>
<tr>
<td>μ</td>
<td>- Coefficient of friction</td>
</tr>
<tr>
<td>μₙₙₕ</td>
<td>- Coefficient of friction when starting</td>
</tr>
<tr>
<td>μₚₚ</td>
<td>- Coefficient of friction for bearing</td>
</tr>
<tr>
<td>σ</td>
<td>Mpa Nominal axial stress</td>
</tr>
<tr>
<td>σₚₚ</td>
<td>Mpa Real axial stress</td>
</tr>
<tr>
<td>σₚₚₕ</td>
<td>Mpa Total stress</td>
</tr>
<tr>
<td>τ</td>
<td>Mpa Nominal shear stress</td>
</tr>
<tr>
<td>τₚₙₚ</td>
<td>Mpa Real shear stress</td>
</tr>
<tr>
<td>η</td>
<td>- Theoretical direct efficiency</td>
</tr>
<tr>
<td>ηₙₙₕ</td>
<td>- Theoretical indirect efficiency</td>
</tr>
<tr>
<td>ηₚₚₕ</td>
<td>- Real direct efficiency</td>
</tr>
<tr>
<td>ηₚₚₕ</td>
<td>- Real indirect efficiency</td>
</tr>
<tr>
<td>θ</td>
<td>° Angle of twist</td>
</tr>
<tr>
<td>ω</td>
<td>rad/s² Angular acceleration</td>
</tr>
<tr>
<td>Ω</td>
<td>mm × rpm Speed quotient, (n_p \times d_o)</td>
</tr>
</tbody>
</table>
SKF – the knowledge engineering company

From the company that invented the self-aligning ball bearing 100 years ago, SKF has evolved into a knowledge engineering company that is able to draw on five platforms to create unique solutions for its customers. These platforms include bearings, bearing units and seals, of course, but extend to other areas including lubricants and lubrication systems, critical for long bearing life in many applications; mechatronics that combine mechanical and electronics knowledge into systems for more effective linear motion and sensorized solutions; and a full range of services, from design and logistics support to condition monitoring and reliability systems.

Though the scope has broadened, SKF continues to maintain the world’s leadership in the design, manufacture and marketing of rolling bearings, as well as complementary products such as radial seals. SKF also holds an increasingly important position in the market for linear motion products, high-precision aerospace bearings, machine tool spindles and plant maintenance services.

The SKF Group is globally certified both to ISO 14001, the international standard for environmental management, as well as OHSAS 18001, the health and safety management standard. Individual divisions have been approved for quality certification in accordance with either ISO 9000 or QS 9000.

With some 100 manufacturing sites worldwide and sales companies in 70 countries, SKF is a truly international corporation. In addition, our distributors and dealers in some 15,000 locations around the world, an e-business marketplace and a global distribution system put SKF close to customers for the supply of both products and services. In essence, SKF solutions are available wherever and whenever customers need them. Overall, the SKF brand and the corporation are stronger than ever. As the knowledge engineering company, we stand ready to serve you with world-class product competencies, intellectual resources, and the vision to help you succeed.

Evolving by-wire technology
SKF has a unique expertise in fast-growing by-wire technology, from fly-by-wire, to drive-by-wire, to work-by-wire. SKF pioneered practical fly-by-wire technology and is a close working partner with all aerospace industry leaders. As an example, virtually all aircraft of the Airbus design use SKF by-wire systems for cockpit flight control.

SKF is also a leader in automotive by-wire technology, and has partnered with automotive engineers to develop two concept cars, which employ SKF mechatronics for steering and braking. Further by-wire development has led SKF to produce an all-electric forklift truck, which uses mechatronics rather than hydraulics for all controls.

Seals
Bearings and units
Lubrication systems
Mechatronics
Services
Harnessing wind power
The growing industry of wind-generated electric power provides a source of clean, green electricity. SKF is working closely with global industry leaders to develop efficient and trouble-free turbines, providing a wide range of large, highly specialized bearings and condition monitoring systems to extend equipment life of wind farms located in even the most remote and inhospitable environments.

Working in extreme environments
In frigid winters, especially in northern countries, extreme sub-zero temperatures can cause bearings in railway axleboxes to seize due to lubrication starvation. SKF created a new family of synthetic lubricants formulated to retain their lubrication viscosity even at these extreme temperatures. SKF knowledge enables manufacturers and end user customers to overcome the performance issues resulting from extreme temperatures, whether hot or cold. For example, SKF products are at work in diverse environments such as baking ovens and instant freezing in food processing plants.

Developing a cleaner cleaner
The electric motor and its bearings are the heart of many household appliances. SKF works closely with appliance manufacturers to improve their products' performance, cut costs, reduce weight, and reduce energy consumption. A recent example of this cooperation is a new generation of vacuum cleaners with substantially more suction. SKF knowledge in the area of small bearing technology is also applied to manufacturers of power tools and office equipment.

Maintaining a 350 km/h R&D lab
In addition to SKF’s renowned research and development facilities in Europe and the United States, Formula One car racing provides a unique environment for SKF to push the limits of bearing technology. For over 50 years, SKF products, engineering and knowledge have helped make Scuderia Ferrari a formidable force in F1 racing. (The average racing Ferrari utilizes more than 150 SKF components.) Lessons learned here are applied to the products we provide to automakers and the aftermarket worldwide.

Delivering Asset Efficiency Optimization
Through SKF Reliability Systems, SKF provides a comprehensive range of asset efficiency products and services, from condition monitoring hardware and software to maintenance strategies, engineering assistance and machine reliability programs. To optimize efficiency and boost productivity, some industrial facilities opt for an Integrated Maintenance Solution, in which SKF delivers all services under one fixed-fee, performance-based contract.

Planning for sustainable growth
By their very nature, bearings make a positive contribution to the natural environment, enabling machinery to operate more efficiently, consume less power, and require less lubrication. By raising the performance bar for our own products, SKF is enabling a new generation of high-efficiency products and equipment. With an eye to the future and the world we will leave to our children, the SKF Group policy on environment, health and safety, as well as the manufacturing techniques, are planned and implemented to help protect and preserve the earth’s limited natural resources. We remain committed to sustainable, environmentally responsible growth.