HOW TO SIZE A BALL SCREW
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Ball Screw Selection Example:

**Specification:**
Equipment: Transfer Table  
Screw Orientation: **Horizontal**  
Load Supported on Dove Tail Ways: .20 Coefficient of friction  
Load is 2500 lbs. Max (combined weight of product and table)  
Stroke Length: 38”  
Travel rate: 600 inches per minute (Max.)  
Input RPM: 2400  
Duty Cycle: 20 cycles per hour, 16 hours per day, 250 days per year  
Required Life: 5 years

**Steps:**

1. **Determine Required Life (Inches):**

   \[ \frac{38”}{stroke} \times 2 \text{ strokes/cycle} \times 20 \text{ cycles/hr} \times 16 \text{ hrs/day} \times 250 \text{ days/year} \times 5 \text{ years} = 30,400,000 \text{ inches} \]

2. **Determine Thrust Load on Ball Screw – Multiply the thrust load by the coefficient of sliding friction (for horizontal application):**

   2500 lbs. * .20 Coefficient of Friction = 500 lbs.  
   Use this load for life calculations. *(If load varies during the stroke or cycle, an equivalent load calculation can be utilized page 9)*

3. **Determine Required Ball Screw Dynamic Axial Loading to Achieve Required Life:**

   Using formula on page 9, input the 500 lbs. thrust load (Or equivalent load) and the required life.  
   The result is the minimum rated load for a ball screw to achieve the required life.

   \[ \left( \frac{\text{Rated Load (P_r)}}{\text{Actual Load (P_t)}} \right)^3 \times 1,000,000 \text{ in.} = \text{Life of assembly under actual load} \]

   \[ \frac{P_r}{500 \text{ lbs}} \times 1,000,000 \text{ in.} = 30,400,000 \text{ inches} \]

   \[ P_r \times \frac{30,400,000”}{1,000,000} = 30.4 \times (500)^3 \]

   \[ P_r = \frac{3}{30.4} \times (500)^3 = 1561 \text{ lbs} \]

4. **Determine Lead of the Screw:**

   Travel Rate:

   \[ \text{RPM} = \frac{\text{Velocity (inches/min.)}}{\text{Lead (inches/rev.)}} \]

   \[ \frac{600”}{\text{min Travel Rate}} \times \frac{2400 \text{ RPM}}{2400} = .250” \text{ per revolution (Lead)} \]
USE THIS QUICK REFERENCE CHART TO SELECT APPROPRIATE BALL SCREW MODEL

<table>
<thead>
<tr>
<th>MODEL</th>
<th>SCREW DIA. X LEAD</th>
<th>SCREW RATED LOAD</th>
<th>SCREW MINOR DIA.</th>
<th>CATALOG PAGE NUMBER</th>
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*Denotes Stainless Steel Models

**Ball Screw Selection:**
Load Rating: Requires Ball Screw Operating Load Capacity of **1,561** lbs. Minimum
Smallest diameter screw with **1,561** lbs. (min.) Operating load and a **.250"** lead is the R40

**Calculate Length Between Bearing Supports:**
Length between bearings = Stroke length + ballnut length + Desired over-travel

**38" stroke + 2.347" nut length (page 39) + 1" over-travel = 41.347" between bearings**
(use this length for column load and critical speed calculations)
How to Size a Ball Screw

6 Calculate End Fixity Based on Critical Speed Limits:
Using formula for Critical Speed, rearrange to solve for Fe (End Fixity Variable)

\[ Cs = Fe \times 4,760,000 \times Fs \times \left( \frac{D_{min} \times S_l}{L^2} \right) \]

Cs = Critical Speed (Inches/min.) = 600 in/min.
D_{min} = Minor Diameter (root) of Screw (In.) = .840 (pg 39) (STEP #4)
S_l = Lead of Screw (In.) = .250 Lead (pg 39) (STEP #4)
L = Distance between bearing supports = 41.347” (STEP #5)
Fe = End Fixity Variable (Maximum Value)
  = .36 for Fixed-Free Support Configuration
  = 1.00 for Simple-Simple Configuration
  = 1.47 for Fixed-Simple Configuration
  = 2.23 for Fixed-Fixed Configuration
Fs = Factor of Safety (80% recommended)

Equations below will solve for the minimum end fixity factor based on Travel Rate (600 in/min.)

\[ 600 \text{ in/min.} = Fe(min) \times 4,760,000 \times .80 \times \left( \frac{.840 \times .250}{41.347^2} \right) \]

\[ Fe(min. ) = \frac{600 \times 41.347^2}{4,760,000 \times .8 \times .840 \times .25} = 1.28 \] Select End Fixity Factor larger than 1.28

Thus a Fixed-Simple (Fe = 1.47) is the proper selection

7 Actual Calculated Critical Speed:

This calculated critical speed is based on the Fixed-Simple end fixity arrangement. It is the maximum safe linear speed with this mounting arrangement, screw model and between bearing supports distance. If greater speed is required, a Fixed-Fixed arrangement can be used, recalculate maximum speed based on a fixed-fixed end fixity configuration (Fe=2.23).

\[ Cs = 1.47 \times 4,760,000 \times .8 \times \left( \frac{.840 \times .250}{41.347^2} \right) = 687 \text{ in/minute} \]

(maximum attainable safe linear speed)
8 **Calculate Critical Ball Speed (DN):**

Critical ball speed is the maximum safe linear speed of this model regardless of screw length. In this example DN should not be less than 687” per minute.

\[
DN = \left(\frac{3000}{\text{Ball Screw Diameter}}\right) \times \text{Lead}
\]

\[
DN = \left(\frac{3000}{1.00}\right) \times .250 = 750” \text{ per minute safe linear speed}
\]

9 **Calculate Column Load Limit:**

This calculated column load is the maximum safe compression load allowable based on mounting arrangement, screw model and distance between bearings. In this example the calculated column loading should be greater than 500 lbs. (Step#2).

\[
Pc = Fe \times 14,030,000 \times Fs \times \left(\frac{D_{min}^4}{L^2}\right)
\]

- \(Pc\) = Maximum Compressive Column Load (lbs.) allowable for the given length
- \(D_{min}\) = Minor Diameter (root) of Screw (In.)=.840” (Step #4)
- \(L\) = Maximum unsupported length in compression (inches)= 41.347” (Step #5)
- \(Fe\) = End Fixity Variable
  - = .25 for Fixed-Free Support Configuration
  - = 1.00 for Simple-Simple Support Configuration
  - = **2.00 for Fixed-Simple Support Configuration**
  - = 4.00 for Fixed-Fixed Support Configuration
- \(Fs\) = Factor of Safety (80% recommended)

\[
Pc = 2.00 \times 14,030,000 \times .8 \times \left(\frac{.840^4}{41.347^2}\right) = 6,537 \text{ LBS (max)}
\]

10 **Calculate Drive Torque:**

\[
Td = \frac{S_i \times (P_t)}{2\pi E_{eff}} = .177 \times S_i \times (P_t)
\]

- \(Td\) = Drive torque (in. lbs)
- \(S_i\) = Lead of screw in inches=.250”
- \(P_t\) = Thrust Load (lbs.)= 500 lbs.
- \(E_{eff}\) = Efficiency 90% (min.)

\[
.177 \times 500 \times .250 = 23 \text{ in. lbs torque at constant velocity}
\]
11 Calculate H.P. Required at Constant Velocity:

\[
\text{Horsepower} = \frac{\text{RPM} \times \text{Drive Torque (in.lbs.)}}{63,000} \quad \Rightarrow \quad \frac{2400 \times (\text{RPM}) \times 23 \text{ (in.lbs.)}}{63,000} = .88 \text{ H.P. min.}
\]

12 Specifying Proper Ball Screw Assembly (page 39):

Screw Overall Length = 41.347 between bearings + 1.070 (Type 1A) + 5.050” (Type 3A) = 47.467” OAL

Model Size: **R40**  Ballnut #: **R40-2**  Mounting Flange #: **R40-3**  
Wiper Kit #: **R40-4, R40-4F** (w/flange wiper cap)  
Bearing Mount Part #: **BMR-20** (Radial simple support) non-drive end  
**BMF-20** (Fixed support) drive end  
Ball Screw Machined Ends: **Type 1A** one end and **Type 3A** other End

13 Go to website to get 2D & 3D downloadable drawings:  [www.rockfordballscrew.com](http://www.rockfordballscrew.com)