Ball Screw Selection Example

Given Specifications in	**GOLD**
Resultant Calculations in	**RED**
Catalog Product Data in	**PURPLE**

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

Above specifications to be used to select proper ball screw assembly

STEPS:

1. Determine Required Life (Inches):

38"/stoke * 2 strokes/cycle * 20 cycles/hr * 16 hrs/day * 250 days/year * 5 years =30,400,000 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 7)

3. Determine Required Ball Screw Dynamic Axial Loading to Achieve Required Life (page 7):

Using formula on page 7, 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.

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

$$\left(\frac{P_r}{500\ lbs}\right)^3 * 1{,}000{,}000 \ in. = 30{,}400{,}000 \ inches$$

$$\frac{P_r^{\,3}}{500^3} = \frac{30{,}400{,}000''}{1{,}000{,}000} \longrightarrow P_r = \sqrt[3]{30.4 * (500)^3} = 1561 \text{ (lbs)}$$

4. Determine Lead of the Screw:

Travel Rate (pg 10):

$$RPM = \frac{\textit{Velocity (inches/min.)}}{\textit{Lead (inches/rev.)}}$$

$$\frac{600''/\textit{min Travel Rate}}{2400 \text{ RPM}} = .250'' \textit{per} \text{ revolution (Lead)}$$

USE THIS QUICK REFERENCE CHART TO SELECT APPROPRIATE BALL SCREW

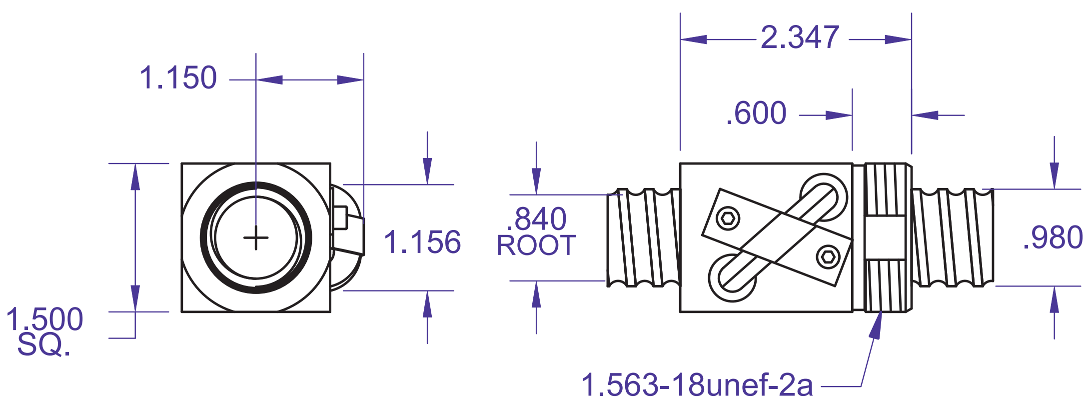
Model	Screw Dia. x Lead	Screw Rated Load	Screw Minor Dia.	Catalog Page Number
R10	.375x.125	150	0.300	22
R11	.375x.125	300	0.300	23
R15*	.375x.125	25	0.300	22
R16*	.375x.125	50	0.300	23
R20,23	.500x.500	850	0.400	24-25
R21*,22*	.500x.500	140	0.400	24-25
R30,31	.631x.200	825	0.500	26
R30A	.631x.200	1,650	0.500	27
R32*	.631x.200	170	0.500	26
R34	.750x.200	1,900	0.650	28
R35	.750x.200	950	0.650	29
R36	.750x.200	160	0.650	29
R37	.750x.500	3,400	0.630	30
R38*	.750x.500	600	0.630	30
R40,41	1.000x.250	1,625	0.840	31
R40A	1.000x.250	3,250	0.840	32
R40RF, 41LF	1.000x.250	3,250	0.840	34
R40B	1.000x.250	4,500	0.840	33
R42	1.000x.250	3,450	0.870	35
R43	1.000x.500	4,250	0.870	36
R44	1.000x1.00	2,300	0.870	37
R45,47	1.150x.200	2,450	1.020	38
R46*	1.150x.200	490	1.020	38
R48	1.063x.625	3,300	0.925	39
R50	1.500x.500	9,050	1.260	40
R50A,51A	1.500x.500	12,900	1.260	41
R53,54	1.500x.250	4,250	1.375	42
R54A	1.500x.250	6,400	1.375	43
R55,56	1.500x1.00	8,000	1.140	44
R57	1.500x.4375	10,500	1.140	45
R58	1.500x1.875	7,350	1.190	46
R60,63	2.250x.500	19,800	1.860	49
R60A	2.250x.500	29,700	1.860	50
R61	2.000x1.00	22,500	1.730	47
R62	2.000x.500	18,000	1.730	48
R70	2.500x.500	22,000	2.220	51
R71	2.500x1.00	26,500	2.220	52
R74	2.500x.250	6,300	2.320	53
R75	2.500x1.50	32,500	2.100	54
R80	3.000x.660	42,000	2.480	55
R90,91	4.000x1.00	85,000	3.338	56

*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 (page 31)



5. Calculate Length Between Bearing Supports:

Length between bearings = Stroke length + ballnut length + Desired over-travel

38" stroke + **2.347** nut length (page 31) + 1" over-travel = **41.347**" between bearings

(use this length for column load and critical speed calculations)

▶ 6. Calculate End Fixity Based on Critical Speed Limits (page 7-8):

Using formula for Critical Speed, rearrange to solve for Fe (End Fixity Variable)

$$Cs = Fe * 4{,}760{,}000 * Fs * \left(\frac{Dmin * S_l}{L^2}\right)$$

Cs	= Critical Speed (Inches/min.) = **600 in./min.**
Dmin	= Minor Diameter (root) of Screw (In.)= **.840** (pg 31) **(STEP #4)**
S_l	= Lead of Screw (In.)= **.250 Lead** (pg 31) **(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.)

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

$$Fe(min.) = \frac{600 * 41.347^2}{4{,}760{,}000 * .8 * .840 * .25} = 1.28$$

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).

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

(maximum attainable safe linear speed)

▶ 8. Calculate Critical Ball Speed (DN) (page 8):

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.

$$DN = (3000\ /\ \text{Ball Screw Diameter}) * \text{Lead}$$

$$DN = (3000\ /\ 1.00) * .250 = 750''\ \text{per minute safer linear speed}$$

9. Calculate Column Load Limit (page 8):

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)**.

$$Pc = Fe * 14{,}030{,}000 * Fs * \left(\frac{Dmin^4}{L^2}\right)$$

Pc	= Maximum Compressive Column Load (lbs.) allowable for the given length
Dmin	= 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)

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

10. Calculate Drive Torque (page 9):

$$Td = \frac{S_l * (P_t)}{2\pi Eff} = .177 * S_l * (P_t)$$

Td	= Drive torque (in. lbs)
S_l	= Lead of screw in inches= .250"
P_t	= Thrust Load (lbs.)= **500 lbs.**
Eff	= Efficiency 90% (min.)

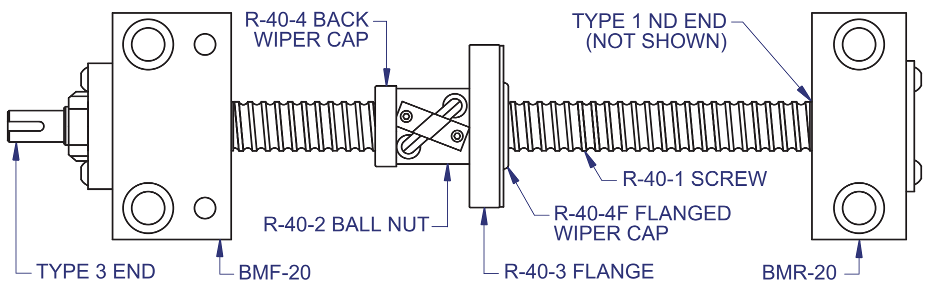
→ .177 * **500** * **.250** = **23** in. lbs torque at constant velocity

11. Calculate H.P. Required at Constant Velocity (page 10):

$$Horsepower = \frac{RPM * Drive\ Torque(in.lbs.)}{63{,}000} \rightarrow \frac{2400\,(RPM) * 23\,(in.lbs.)}{63{,}000} = .88\ H.P.\ min.$$

12. Specifying Proper Ball Screw Assembly (page 31):

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