



Rockford Ball Screw

How To Size A Ball Screw



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

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

Above specifications to be used to select proper ball screw assembly

STEPS:

- 1. Determine Required Life (Inches):

$$38"/\text{stroke} * 2 \text{ strokes/cycle} * 20 \text{ cycles/hr} * 16 \text{ hrs/day} * 250 \text{ days/year} * 5 \text{ years} = 30,400,000 \text{ inches}$$

- 2. Determine Thrust Load on Ball Screw –

Multiply the thrust load by the coefficient of sliding friction (for **horizontal** application):

$$2500 \text{ lbs.} * .20 \text{ Coefficient of Friction} = 500 \text{ lbs.}$$

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.

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

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

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

- 4. Determine Lead of the Screw:

Travel Rate (pg 10):

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

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



USE THIS QUICK REFERENCE CHART TO SELECT APPROPRIATE BALL SCREW MODEL

Model	Screw Dia. X Lead	Screw Rated Load	Screw Minor Dia.	Catalog Page Number
R10	.375x.125	150	0.300	23
R11	.375x.125	300	0.300	24
R12	.375x.125	170	0.295	22
R15*	.375x.125	25	0.300	23
R16*	.375x.125	50	0.400	24
R20, 23	.500x.500	850	0.400	25, 26
R21*, 22*	.500x.500	140	0.500	25, 26
R30,31	.631x.200	825	0.500	27
R30A,31A	.631x.200	1,650	0.500	29
R30RFW, 31LFW	.631x.200	825	0.500	28
R32*	.631x.200	170	0.650	27
R34, 34A	.750x.200	1,900	0.650	30, 31
R35, 35A	.750x.200	950	0.650	32, 33
R36	.750x.200	160	0.630	32
R37	.750x.500	3,400	0.630	34
R38*	.750x.500	600	0.840	34
R40,41	1.000x.250	1,625	0.840	35
R40RFW, R41LFW	1.000x.250	1,625	0.840	36
R40A, 40AR	1.000x.250	3,250	0.840	37, 38
R40RF, 41LF	1.000x.250	3,250	0.840	41
R40B, R40SB	1.000x.250	4,500	0.840	39, 40
R42	1.000x.250	3,450	0.870	42
R43	1.000x.500	4,250	0.870	43

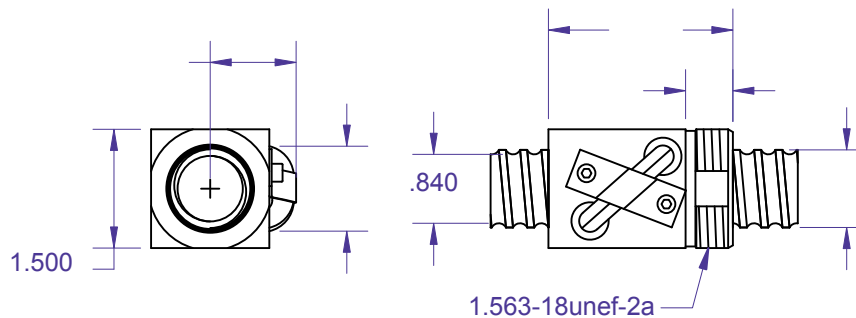
Model	Screw Dia. X Lead	Screw Rated Load	Screw Minor Dia.	Catalog Page Number
R44	1.000x1.00	2,300	0.870	44
R44A	1.000x1.00	4,600	0.870	45
R45,47	1.150x.200	2,450	1.020	46
R46*	1.150x.200	490	1.020	46
R48	1.063x.625	3,300	0.925	47
R50	1.500x.500	9,050	1.260	48
R50A, 51A	1.500x.500	12,900	1.260	49
R53, 54	1.500x.250	4,250	1.375	50
R53A, 54A	1.500x.250	6,400	1.375	51
R55, 56	1.500x1.00	8,000	1.140	52
R57, 57A	1.500x.4375	10,050	1.140	53, 54
R58, 58A	1.500x1.875	7,350	1.190	55, 56
R58B	1.500x1.875	14,700	1.190	57
R61	2.000x1.00	22,500	1.730	58
R62	2.000x.500	18,000	1.730	59
R60,63	2.250x.500	19,800	1.860	60
R60A	2.250x.500	29,700	1.860	61
R70	2.500x.500	22,000	2.220	62
R71	2.500x1.00	26,500	2.220	63
R74	2.500x.250	6,300	2.320	64
R75	2.500x1.50	32,500	2.100	65
R80, 80A, 81A	3.000x.660	42,000	2.480	66, 67
R90, 91	4.000x1.00	85,000	3.338	68

* 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 35)



► 5. Calculate Length Between Bearing Supports:

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

38" stroke + **2.347** nut length (page 35) + 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 35) (STEP #4)
 S_l= Lead of Screw (In.)= **.250 Lead** (pg 35) (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.**)

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

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



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).

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

- ▶ 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)**.

$$P_c = F_e * 14,030,000 * F_s * \left(\frac{D_{min}^4}{L^2} \right)$$

- P_c = 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)
- F_e = 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
- F_s = Factor of Safety (80% recommended)

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

► 10. Calculate Drive Torque (page 9):

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

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

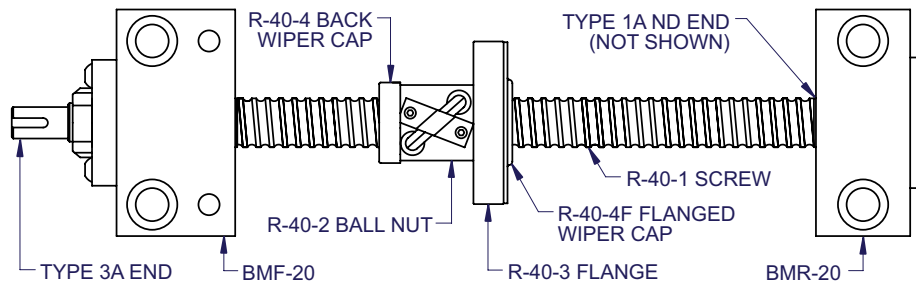
↳ **.177 * 500 * .250 = 23 in. lbs torque at constant velocity**

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

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

► 12. Specifying Proper Ball Screw Assembly (page 35):

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