



Rockford Ball Screw

How To Size A 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 Specification in GOLD
Resultant Calculation in RED
Catalog Product Data in PURPLE

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 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.

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

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

The result is the minimum rated load for a ball screw to achieve the required life.

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

4 Determine Lead of the Screw:

Travel Rate (pg 12):

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

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

USE THIS QUICK REFERENCE CHART TO SELECT APPROPRIATE BALL SCREW MODEL

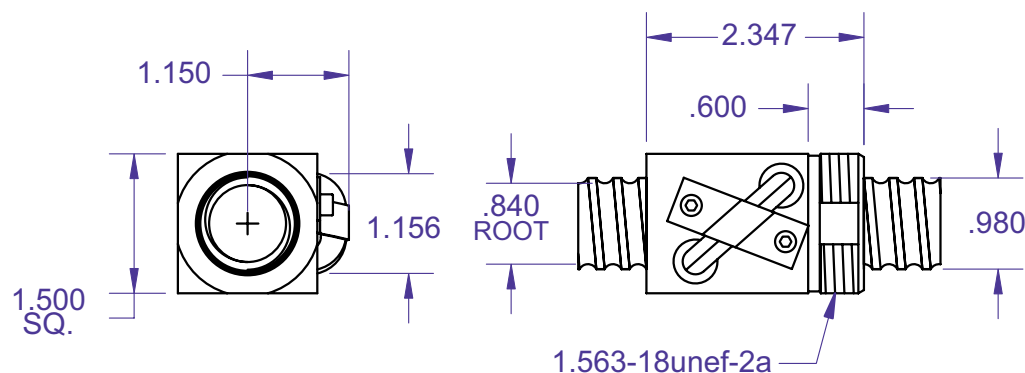
MODEL	SCREW DIA. X LEAD	SCREW RATED LOAD	SCREW MINOR DIA.	CATALOG PAGE NUMBER	MODEL	SCREW DIA. X LEAD	SCREW RATED LOAD	SCREW MINOR DIA.	CATALOG PAGE NUMBER
R10	.375x.125	150	0.300	26	R43	1.000x.250	4,250	0.870	46
R11	.375x.125	300	0.300	28	R44	1.000x1.00	2,300	0.840	47
R12	.375x.125	170	0.295	27	R45, 47	1.150x.200	2,450	1.020	48
R15*	.375x.125	25	0.300	26	R46*	1.150x.200	490	1.020	48
R16*	.375x.125	50	0.300	28	R48	1.063x.625	3,300	0.925	49
R20, 23	.500x.500	850	0.400	29, 30	R50	1.500x.500	9,050	1.260	50
R21*, 22*	.500x.500	140	0.400	29, 30	R50A, 51A	1.500x.500	12,900	1.260	51
R30, 31	.631x.200	825	0.500	31	R53, 54	1.500x.250	4,250	1.375	52
R30A, 31A	.631x.200	1,650	0.500	32	R53A, 54A	1.500x.250	6,400	1.375	53
R30RFW, 31LFW	.631x.200	825	0.500	33	R55, 56	1.500x1.00	8,000	1.140	54
R32*	.631x.200	170	0.500	31	R57	1.500x.4737	10,050	1.140	55
R34, 34A	.750x.200	1,900	0.650	34, 35	R58, 58A	1.500x1.875	7,350	1.190	56, 57
R35, 35A	.750x.200	950	0.650	36, 37	R60, 63	2.250x.500	19,800	1.860	60
R36	.750x.200	160	0.630	36	R60A	2.250x.500	29,700	1.860	61
R37	.750x.500	3,400	0.630	38	R61	2.000x.1.00	22,500	1.730	58
R38*	.750x.500	600	0.630	38	R62	2.000x.500	18,000	1.730	59
R40, 41	1.000x.250	1,625	0.840	39	R70	2.500x.500	22,000	2.220	62
R40C, 41C	1.000x.250	1,625	0.840	43	R71	2.500x1.00	26,500	2.220	63
R40A, 40AR	1.000x.250	3,250	0.840	40, 44	R74	2.500x.250	6,300	2.320	64
R40RF, 41LF	1.000x.250	3,250	0.840	42	R75	2.500x1.50	32,500	2.100	65
R40B	1.000x.250	4,500	0.840	41	R80, 80A, 81A	3.000x.660	42,000	2.480	66, 67
R42	1.000x.250	3,450	0.870	45	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 39)



5 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)

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6 Calculate End Fixity Based on Critical Speed Limits (page 9-10):

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

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

Cs = Critical Speed (Inches/min.) = **600 in./min.**

Dmin= Minor Diameter (root) of Screw (In.) = **.840** (pg 39) (STEP #4)

Sl = 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.**)

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

$$Fe(min.) = \frac{600 * 41.347^2}{4,760,000 * .8 * .840 * .250} = 1.28 \quad \text{Select End Fixity Factor larger than } 1.28$$



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 10):

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 10):

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 11):

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



$$.177 * 500 * .250 = 23 \text{ in. lbs torque at constant velocity}$$

T_d = Drive torque (in. lbs)

S_l = Lead of screw in inches = .250"

P_t = Thrust Load (lbs.) = 500 lbs.

E_{ff} = Efficiency 90% (min.)

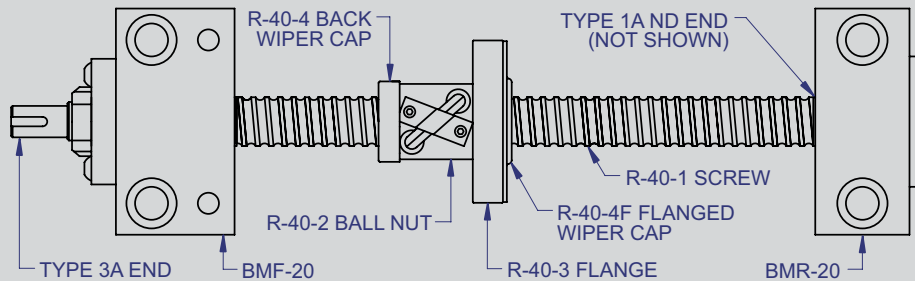
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11 Calculate H.P. Required at Constant Velocity (page 12):

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

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