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

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"/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 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.

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

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

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

4 Determine Lead of the Screw:

Travel Rate:

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

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

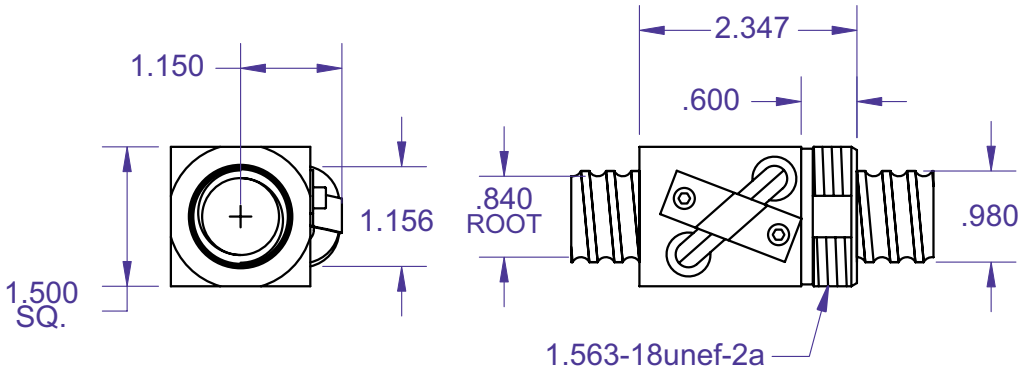
USE THIS QUICK REFERENCE CHART TO SELECT APPROPRIATE BALL SCREW MODEL

MODEL	SCREW DIA. X LEAD	SCREW RATED LOAD	SCREW MINOR DIA.	CATALOG PAGE NUMBER
R10	.375x.125	150	0.300	26
R11	.375x.125	300	0.300	28
R12	.375x.125	170	0.295	27
R15*	.375x.125	25	0.300	26
R16*	.375x.125	50	0.300	28
R20, 23	.500x.500	850	0.400	29, 30
R21*, 22*	.500x.500	140	0.400	29, 30
R30, 31	.631x.200	825	0.500	31
R30A, 31A	.631x.200	1,650	0.500	32
R30RFW, 31LFW	.631x.200	825	0.500	33
R32*	.631x.200	170	0.500	31
R34, 34A	.750x.200	1,900	0.650	34, 35
R35, 35A	.750x.200	950	0.650	36, 37
R36	.750x.200	160	0.630	36
R37	.750x.500	3,400	0.630	38
R38*	.750x.500	600	0.630	38
R40, 41	1.000x.250	1,625	0.840	39
R40C, 41C	1.000x.250	1,625	0.840	43
R40A, 40AR	1.000x.250	3,250	0.840	40, 44
R40RF, 41LF	1.000x.250	3,250	0.840	42
R40B	1.000x.250	4,500	0.840	41
R42	1.000x.250	3,450	0.870	45

MODEL	SCREW DIA. X LEAD	SCREW RATED LOAD	SCREW MINOR DIA.	CATALOG PAGE NUMBER
R43	1.000x.250	4,250	0.870	46
R44	1.000x1.00	2,300	0.840	47
R45, 47	1.150x.200	2,450	1.020	48
R46*	1.150x.200	490	1.020	48
R48	1.063x.625	3,300	0.925	49
R50	1.500x.500	9,050	1.260	50
R50A, 51A	1.500x.500	12,900	1.260	51
R53, 54	1.500x.250	4,250	1.375	52
R53A, 54A	1.500x.250	6,400	1.375	53
R55, 56	1.500x1.00	8,000	1.140	54
R57	1.500x.4737	10,050	1.140	55
R58, 58A	1.500x1.875	7,350	1.190	56, 57
R60, 63	2.250x.500	19,800	1.860	60
R60A	2.250x.500	29,700	1.860	61
R61	2.000x.1.00	22,500	1.730	58
R62	2.000x.500	18,000	1.730	59
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



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)

6 Calculate End Fixity Based on Critical Speed Limits:
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 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.)

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

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

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.

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

$$DN = (3000/1.00) * .250 = 750"\ \ per\ minute\ safe\ linear\ speed$$

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)**.

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

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)

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

10 Calculate Drive Torque:

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

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

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

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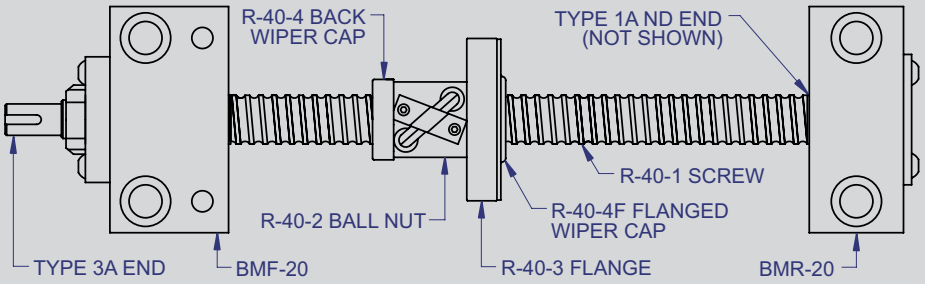
11 **Calculate H.P. Required at Constant Velocity:**

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

12 **Specifying Proper Ball Screw Assembly (page 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**