Design Considerations

RS Series

* Rolled Ball Screw
* Tapped Ball Nut
* English Leads
* English Diameters
* Pre-loaded & Non-preloaded Nuts
* Simple, Fixed and Rigid Housings
* Aluminum or Steel Housings
* Available Sizes

  0.500 inch dia., 0.200 inch lead
  0.500 inch dia., 0.500 inch lead
  0.625 inch dia., 0.200 inch lead
  0.625 inch dia., 1.000 inch lead
  0.750 inch dia., 0.200 inch lead
  0.750 inch dia., 0.500 inch lead
  1.000 inch dia., 0.250 inch lead
  1.000 inch dia., 0.500 inch lead
  1.000 inch dia., 1.000 inch lead
  1.500 inch dia., 0.250 inch lead
  1.500 inch dia., 0.500 inch lead
  1.500 inch dia., 1.000 inch lead
  1.500 inch dia., 2.000 inch lead

PS Series

* Precision Rolled Ball Screw
* Ground Ball Nut
* English & Metric Leads
* English & Metric Diameters
* Pre-loaded & Non-preloaded Nuts
* Simple, Fixed and Rigid Housings
* Aluminum or Steel Housings
* Available Sizes

  0.625 inch dia., 0.200 inch lead
  0.750 inch dia., 0.200 inch lead
  16 mm diameter, 5 mm lead
  16 mm diameter, 10 mm lead
  16 mm diameter, 16 mm lead
  20 mm diameter, 5 mm lead
  20 mm diameter, 20 mm lead

GS Series

* Precision Ground Ball Screw
* Ground Ball Nut
* English & Metric Leads
* English & Metric Diameters
* Pre-loaded Nuts Only
* Simple, Fixed and Rigid Housings
* Aluminum or Steel Housings
* Available Sizes

  0.625 inch dia., 0.200 inch lead
  0.750 inch dia., 0.200 inch lead
  16 mm diameter, 5 mm lead
  16 mm diameter, 16 mm lead
  20 mm diameter, 5 mm lead
  20 mm diameter, 20 mm lead

Ball Screw Series	Bidirectional Repeatability Preloaded Nut inches (mm)	Backlash Non-preloaded Nut inches (mm)	Lead Error inch/ft (mm/300 mm)	Maximum Travel Length inches (mm)	Turcite Nut Option	Smoothness with Ball Nut	Audible Noise	Screw Cost
RS Series 0.500 - 0.750 inch diameters	+/- 0.0002 (0,0050)	< 0.008 (0,203)	< 0.003 (0,075)	67 (1702)	Yes	Good	Loudest	Lowest
RS Series 1.000 inch diameters	+/- 0.0002 (0,0050)	< 0.009 (0,229)	< 0.009 (0,229)	137 (3480)	Yes	Good	Loudest	Medium
RS Series 1.500 inch diameters	+/- 0.0002 (0,0050)	< 0.013 (0,330)	< 0.009 (0,229)	134 (3404)	No	Good	Loudest	Medium
PS Series 0.625 inch & 16 mm diameters	+/- 0.0002 (0,0050)	< 0.003 (0,075)	< 0.002 (0,050)	73 (1854)	No	Very Good	Quiet	Low
PS Series 0.750 inch & 20 mm diameters	+/- 0.0002 (0,0050)	< 0.003 (0,075)	< 0.002 (0,050)	112 (2845)	No	Very Good	Quiet	Low
GS Series 0.625 inch & 16 mm diameters	+/- 0.0001 (0,0025)	No option for Non-preloaded Nut	< 0.0005 (0,012)	40 (1016)	No	The Best	Quietest	High
GS Series 0.750 inch & 20 mm diameters	+/- 0.0001 (0,0025)	No option for Non-preloaded Nut	< 0.0005 (0,012)	59 (1499)	No	The Best	Quietest	High

Ball screws are the lead screw of choice for high duty cycle, high speed, and long life applications. The ball screw nut uses one or more circuits of recirculating steel balls which roll between the nut and ball screw threads (grooves), providing an efficient low friction system. Using a higher lead ball screw (a 0.500 inch lead instead of a 0.200 inch lead) will offer greater carriage speed for applications requiring rapid traverse or fast, short incremental moves. Low wear and long life are key features of a ball screw system.

Ball screws from LinTech are available in three different versions. The rolled ball screw system (RS series) utilizes a tapped nut with a standard accuracy rolled ball screw thread. The precision ball screw system (PS series) utilizes a ground nut with a higher accuracy rolled ball screw thread. The ground ball screw system (GS series) utilizes a ground nut with a high accuracy ground ball screw thread.

A ground ball screw will offer better open loop (no encoder feedback) position accuracy versus a rolled or precision rolled ball screw. Some of the screws are available with preloaded nuts. The preloaded nut assembly offers high *bidirectional* repeatability by eliminating backlash.

The Turcite nut option is only available on the RS series and it operates similar to an acme screw. The Turcite nut grooves ride in the matching ball screw grooves, much like the ordinary nut and bolt system. This produces a higher friction system than a ball nut, since there are no rolling elements between the Turcite nut and the ball screw threads. For applications requiring low speeds, low audible noise, very good smoothness, and have a low duty cycle, the Turcite nut works fine. Also, in vertical applications with light loads, the Turcite nut may prevent the back driving of the attached load.

Consideration	Turcite Nut	Ball Screw Nut			Comments
		Rolled (RS)	Precision (PS)	Ground (GS)	
Audible noise	least audible noise	most audible noise	less audible noise than the RS series	less audible noise than the PS series	**Turcite**: no rolling elements provide for quiet operation. **Ball**: recirculating balls in nut assembly transmit audible noise during motion; due to more accurate machining procedures - precision & ground ball screws are quieter than rolled ball screws.
Back Driving Loads	may prevent back driving	can easily back drive a load	can easily back drive a load	can easily back drive a load	**Turcite**: good for light load, vertical applications. **Ball**: recirculating balls in nut assembly produce a low friction system; vertical applications may require a brake to hold the load when no power is applied to the motor.
Backlash *non-preloaded nut*	will increase with wear	constant	constant	constant	**Turcite**: no preloaded nut assembly available. **Ball**: preloaded nut assembly eliminates backlash.
Duty Cycle	low to medium (< 50 %)	high (100 %)	high (100 %)	high (100 %)	**Turcite**: low duty cycle due to high sliding friction. **Ball**: high duty cycle due to recirculating balls in nut assembly - high efficiency & low friction system.
Life	shorter due to higher friction	longest	longest	longest	**Turcite**: mechanical wear related to duty cycle, load & speed. **Ball**: minimal wear if operated in proper environment, within load specifications, and periodically lubricated.
Relative - Cost	least expensive	least expensive ball nut	slightly more than RS series	most expensive	**Turcite**: inexpensive nut. **Ball**: due to more accurate manufacturing procedures precision rolled & ground ball screws are more expensive.
Screw Efficiency	medium (60 %)	high (90 %)	high (90 %)	high (90 %)	**Turcite**: low efficiency due to higher sliding friction. **Ball**: high efficiency due to recirculating balls in nut assembly - low friction system.
Smoothness	smoothest	least smooth	medium smoothness	smoothest	**Turcite**: very smooth at very low speeds. **Ball**: smoothness is constant through a wide speed range; due to more accurate manufacturing procedures precision rolled & ground ball screws are smoother than rolled ball screws.
Speeds	low	high	high	high	**Turcite**: high friction can causes excess heat & wear at high speeds. **Ball**: recirculating balls in nut provide for a high speed system due to low friction & high efficiency.

Specifications subject to change without notice

Simple Support Housing
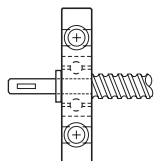
* Black Anodized Aluminum Finish
* Black Oxide Steel Finish
* 1 Sealed Radial Bearing
* No Lubrication Required
* Base or Face Mounted

Fixed (LT) Support Housing
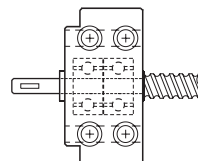
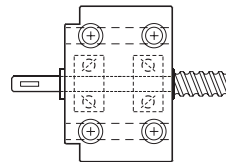* Black Anodized Aluminum Finish
* Black Oxide Steel Finish
* 2 Back to Back Sealed Radial Bearings
* No Lubrication Required
* Lip Seals
* Base or Face Mounted
* Motor Mount Options

Fixed (HT) Support Housing
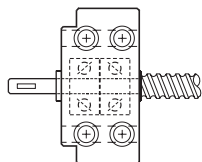
* Black Anodized Aluminum Finish
* Black Oxide Steel Finish
* 2 Back to Back Angular Contact Bearings
* No Lubrication Required
* Lip Seals
* Base or Face Mounted
* Motor Mount Options

Rigid Support Housing

* Black Anodized Aluminum Finish
* Black Oxide Steel Finish
* 2 Separated Angular Contact Bearings
* No Lubrication Required
* Lip Seals
* Base or Face Mounted
* Motor Mount Options

Possible Configurations	Maximum Speed (rpm)	Thrust Load	Compression Load versus Screw Length	Breakaway Torque	Screw End Play (Backlash)	Support Housing Cost
Simple-Simple	Low	Low	Low	Lowest	Some	Lowest
Fixed(LT)-Simple	Low	Medium	Low	Low	None	Low
Fixed(HT)-Simple	Low	High	Low	Medium	None	Medium
Rigid-Simple	Medium	High	Medium	Medium	None	High
Rigid-Rigid	High	High	High	Highest	None	Highest

Specifications subject to change without notice

LinTech ®

Overview

LINTECH's ball screw assemblies can be used in a wide variety of Motion Control applications. Proper selection of an assembly will yield a system that meets the performance requirements with trouble free long term operation. The following steps should be used as a guide to aid in the selection process.

Step 1 - Initial system requirements
Step 2 - Determine the desired travel life
Step 3 - Determine the effect of the load
Step 4 - Determine the maximum safe speed
Step 5 - Determine the safe compression load
Step 6 - Check the Support Configuration
Step 7 - Applying safety factors
Step 8 - Review other issues

Step 1 - Initial System Requirements

Several important items should be identified initially. They are: plane of operation, total load weight, system maximum speed, desired travel length, and system repeatability. Answers to these items are required as we move onto the next steps.

Example #1:

Plane of Operation   = Vertical
Load Weight   = 200   lbs   plus (+)
   * 100 pound force required to drill through a material
      the last 3 inches of a 32 inch downward move
System Speed   = 5   inches / second
Travel Length   = 32   inches
   * 29 inches of travel is required for part loading
System Repeatability   = 0.001 inches (bidirectional)

Step 2 - Determine the Desired Travel Life

Life consists of the number of inches traveled by the ball screw nut versus the applied load. A simple calculation for required ball screw life is the starting point to aid in selecting the correct ball screw assembly.

Example #1 Continued:

assembly needs to last 6 years
with
a 32 inch move down, then up 32 inches every 90 seconds
for
9 hours per day
for
5 days per week
and
50 weeks per year

$$\frac{(32 \times 2)\ inches}{90\ sec} \times \frac{60\ sec}{1\ min} \times \frac{60\ min}{1\ hr} \times \frac{9\ hr}{1\ day} \times$$

$$\frac{5\ days}{1\ week} \times \frac{50\ weeks}{1\ yr} \times 6\ years = \mathbf{34{,}600{,}000}\ inches\ of\ travel$$

Step 3 - Determine the Effect of the Load

Will the ball screw assembly be mounted in a horizontal or vertical plane? We need to determine the load as seen by the "ball screw nut" and as seen by the "support housings". In a horizontal application, the screw and support housing only see the load times the coefficient of friction for the linear bearing structure. Coefficient of friction for various linear bearing surfaces differ, however for recirculating ball bearing style a 0.01 value can be used. In a vertical application, the ball screw nut and the support housing see the entire load as an axial force. Whenever possible, it is best to set-up the ball screw assembly in "Tension Loading" versus "Compression Loading" for vertical applications. This can be done by mounting the "Fixed" or "Rigid" motor mount housing above the screw.

Example #1 Continued:

Vertical Application

Operating Load   Load
(as seen by lead screw) **=**   Weight

=   200 lbs for 29 inches
        300 lbs for 3 inches

We decide to be on the safe side. So we anticipate the entire 300 pounds is seen by the nut all the time and we want a safety margin of 2 times. Therefore we look for a screw that can handle 600 pounds for 34.6 million inches of travel (from step 2).

Example #1 Continued (from page 10):

From the graph we determine the RS075020 suites our needs as it has a life of 40 million inches of travel with a load of 600 pounds.

Step 4 - Determine the Maximum Safe Speed

This is a mechanical limitation defined as the top speed which, if exceeded, has the potential to cause excessive vibration, and damage to the screw, or support bearings. Screw charts are provided for all screws in RPM of the screw. To convert to inches/second, multiply by the desired screw lead.

Example #1 Continued:

Maximum linear speed = 5 inches / second
Selected screw   = RS075020

$$\frac{5 \text{ inches}}{\text{sec}} \quad X \quad \frac{\text{rev}}{.200 \text{ inch}} \quad X \quad \frac{60 \text{ sec}}{\text{min}} \quad = \quad \textbf{1500} \text{ RPM}$$

Example #1 Continued (from pages 38-45):

Maximum travel length   = 32 inches
Selected screw   = RS075020
Repeatability   = 0.001 inches
                     (use Preloaded nut)
Nut length   = 6.080 inches

     32 inches + 6.080 inches = **38** inches

Example #1 Continued (from page 43):

From the maximum speed graph we determine a Fixed-Simple (Simple-Simple) support configuration would give us 1640 screw RPM with 40 inches between support housings. Because we want a safety margin (in case our linear speed requirement goes up) we select a Rigid-Simple configuration which will give us 2410 screw RPM with 40 inches between support housings.

Step 5 - Determine the Safe Compression Load

A compression load tends to compress or buckle a ball screw shaft. If a sufficiently heavy load is applied to a nut with a long ball screw in a horitontal application, the ball screw could buckle. In a vertical application, if a Fixed or Rigid motor driven housing is mounted below the ball screw, the ball screw weight & load weight could buckle the screw. Therefore, in a vertical application, installing the motor driven support housing above the ball screw puts the ball screw assembly in a tension mode.

Example #1 Continued:

In this vertical application, the ball screw assembly will have the motor driven Rigid support housing mounted above the screw. This puts the ball screw assembly in a Tension mode. Therefore, we do not need to be concerned about a safe Compression load.

Step 6 - Check the Support Configuration

Every support housing on a ball screw assembly has a life based upon the thrust load applied versus the number of screw revolutions. Typically, the motor driven support housing will experience most of the thrust load exerted in a ball screw assembly. First calculate the torques required to move the load, and then calculate the forces exerted on the support housing.

Example #1 Continued (from page 13):

Acceleration Torque   =   250 oz-in
Constant Speed Torque =   230 oz-in
Deceleration Torque   =   175 oz-in

Using the worst case scenario:

$$C_T \quad = \quad \frac{2\pi e \ (\ T_{Total} \ )}{d} \quad \frac{lb}{(16 \ oz)} \quad lbs$$

$$C_T \quad = \quad \frac{2\pi .90 \ (\ 250 \ )}{.200} \quad \frac{lb}{(16 \ oz)} \quad lbs$$

$$C_T \quad = \quad \textbf{442} \quad lbs$$

Example #1 Continued (from page 41):

At 442 pounds of thrust load the Rigid support housing has 350 million screw revolutions or 70 million inches of travel life. Our 2 times safety margin is still in effect.

$$\frac{350,000,000 \text{ revs}}{} \quad X \quad \frac{.200 \text{ inch}}{\text{rev}} \quad = \quad \textbf{70,000,000} \text{ inches of travel}$$

Step 7 - Applying Safety Factors

The steel balls of a ball screw nut, or the materials of a Turcite nut, are always subject to repeated stresses in a ball screw application. A key element in the selection process is to determine an adequate safety margin for load/life of a ball screw and support housings.

Static Loads

These loads can exert an extreme force upon the screw & nut in a non-moving state. If a static load rating of a particular ball screw assembly is exceeded, a localized permanent deflection between the recircutating steel balls of a ball nut and the screw, could cause the system to not operate smoothly, or fail outright. To ensure proper life, external forces should never come close to the static rating. Repeated forces at or near the maximum rating can fatigue the elements causing premature failure.

Some static forces will be known and can be accounted for (i.e. drilling, insertion, stamping, engraving, etc.). Other unexpected forces that are difficult to determine could come from vibrations, impacts, or inertial forces. Thus, a safety factor should be considered to account for these forces. This factor represents the ratio of the components load capability versus the applied load.

Operation Conditions	Loading Type	Min. Safety Factor
Stationary	No applied impact or vibration loads.	1.0 - 2.0
	High impact, vibration or thrust loads are present.	2.0 - 6.0

Dynamic Loads

These loads exert a force upon the screw & nut while the screw is in motion. If the rated load of a particular ball screw assembly is exceeded, there is a resultant reduction in the overall travel life. Safety factors are important for these ratings as well. They can help to account for vibration, impact, backdriving, and starting/stopping loads which can reduce the overall life.

As a ball screw driven system moves, there are usually resultant vibrations & impact loads as a by-product. The rate at which the ball screw nut begins to move a load, can have a large impact on the life of a ball screw assembly. The nut sees this start/stop rate as a shock load each time. These and other variable loads cannot be calculated precisely. Thus, a safety factor should be applied to account for these loads which could fatigue the system into premature failure. A safety margin also helps to compensate for changing loads, changing speeds, changing acceleration rates, and lack of lubrication.

Impacts or Vibration	Speed (in/sec)	Acceleration (G's)	Min. Safety Factor
None	< 5	< 0.25	1.0 - 2.0
Small	5.0 - 9.9	0.25 - 0.49	2.0 - 3.0
Medium	10.0 - 20.0	0.50 - 0.99	3.0 - 4.0
Large	> 20	> 1	4.0 - 8.0

Design Considerations

Step 8 - Review Other Issues

Audible Noise

As the steel balls of a ball nut circulate through the nut, audible noise is created. The level of this audible noise is determined by the ball screw type, nut design, screw lead, screw rotational speed, coupling style, and motor type used to rotate the screw. Generally speaking, a GS series operates quieter than a PS series, and a PS series operates quieter than a RS series. Because there are no rolling elements in a Turcite nut, this nut option can operate very quietly.

Couplings

The coupling selected can have a major influence on the overall performance of a ball screw assembly. Couplings have a price versus performance relationship. Generally speaking, the C type coupling works fine for stepper driven applications with speeds below 3 inches per second & acceleration rates below .5 g's. The H type coupling works fine for all stepper driven applications, and also works with servo driven applications with speeds below 20 inches per second and acceleration rates below 1 g. The G type coupling will work fine in all applications. Also, for vertical applications, a H type or G type coupling should be used to minimize windup.

Duty Cycle

Duty cycle consists of distance of movement, speed, acceleration rate, and dwell time between moves. In high duty cycle applications, the use of a ball nut is typically a better choice than a Turcite nut. Frequency of lubrication can also become a factor in the overall life of a ball screw assembly in a high duty cycle application. Regularly scheduled lubrication, or an automatic lubrication system, should be considered.

Maintenance/Service Issues

Regular lubrication of a ball screw for most applications is always required. If regular lubrication is impossible, then using a larger safety margin for selecting a ball screw assembly, or the use of an automatic lubrication system, is recommended. The support housings are sealed and require no lubrication or other maintenance.

Motor Control System

The motor control system selected can have a profound effect on the life of a ball screw assembly. Servo motor systems and their peak torque availability can produce high thrust loads to a ball screw assembly. Having too high an acceleration rate, or slamming a nut against a support housing, can cause large thrust forces. These forces can cause a coupling to break, a nut to be damaged, a ball screw to be bent, or a support housing to be damaged. Care should be taken in selecting the correct motor control system to operate a particular ball screw assembly.
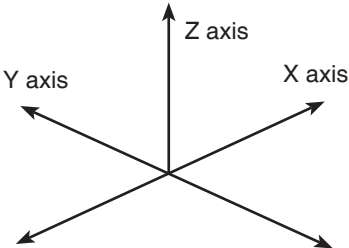
Mounting

The ball screw assembly life, and operation, is highly dependent upon how it is mounted. A ball screw assembly should only see straight axial loads (thrust loads), and never should experience side loads or moment loads. In order to obtain optimum results, the ball screw assembly should be used with a linear bearing system. The linear bearing system therefore supports all the system load forces directly and not the ball screw assembly. The ball screw assembly must also be mounted parallel to the linear rails.
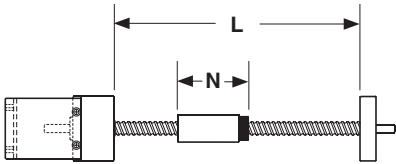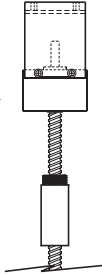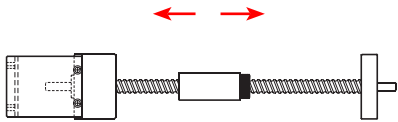
Operational Environment

The environment that a ball screw assembly is used in can greatly influence its life. Bellows, chrome plating, or other special requirements may be needed for high temperature, high humidity/moisture, vacuum rated, clean room, cutting, machining (chip/particulates), cutting fluids or chemical compound applications.

Repeatability versus Accuracy

Repeatability is defined as the ability of a ball screw assembly to go back to a set and known position, over and over again. Accuracy is defined as the ability of a ball screw assembly to move from one location to another and the actual exact distance to get there. Repeatability is noncumulative, while accuracy is cumulative.

LinTech® Ball Screw Assemblies

Z axis
Y axis
X axis

Name	_____ **Date** _____
Company	_____
Address	_____
City	_____ **State** _____ **Zip** _____
Phone	( ) _____ **Fax** ( ) _____

Positioning System Specifications

	X	Y	Z		X	Y	Z
Ball Screw Type (rolled, precision, ground)				**Duty Cycle** (%)			
English or Metric (E or M)				**Travel Length (L-N)** (inches or mm)			
Shock/Impact Loads (none, low, medium, high)				**Repeatability** (inches or mm)			
Overall Travel Life (millions of inches or Km)				**Lead Error** (inch/ft or mm/300mm)			
Maximum Accel (inches/sec^2 or m/sec^2)				**Nut Flange Type** (round, vertical, "L")			
Maximum Speed (inches/sec or m/sec)				**Motor Frame Size** (NEMA 23, 34, 42, other)			
Most Difficult Move Profile — Distance (in or mm)				**Encoder** (Resolution)			
Most Difficult Move Profile — Time (sec)				**Power-off Brake** (Yes or No)			

Special Requirements	☐ High Temperature	☐ Clean Room	☐ Maximum Smoothness	☐ Motor Wrap
	☐ Vacuum Rated	☐ High Moisture	☐ Low Audible Noise	☐ Other (explain below)

Screw & Support Housing Loads

Load Weight as Seen by the Ball Screw (pounds)

Horizontal Application

L

N

Load W= _____

Travel Length (L-N)

Vertical Application

Load W= _____

Total Load (W + T) _____

Additional Thrust Load

Force T= Load applied to the screw from an external source

Application Details

(please describe and attach separate sketch if required)

Screw Travel Life

The life of a ball screw is determined by the load applied to the nut, and the number of inches (mm) traveled by the nut. The load weight "as seen by the ball screw" depends upon screw orientation. Any side, or moment, loads that the screw sees, will reduce life. These forces should be eliminated by using a linear bearing system.

$$L = \left[\frac{R}{F} \right]^3 \times B$$

L = normal travel life (millions of inches or Km).

R = rated dynamic load capacity of nut at 1 million inches of travel or 25 Km.

F = user applied axial load.

B = either 1 (for millions of inches) or 25 (for Km).

Horizontal Application

$$\text{Applied Axial Load (as seen by lead screw)} = \text{Load Weight} \times \mu$$
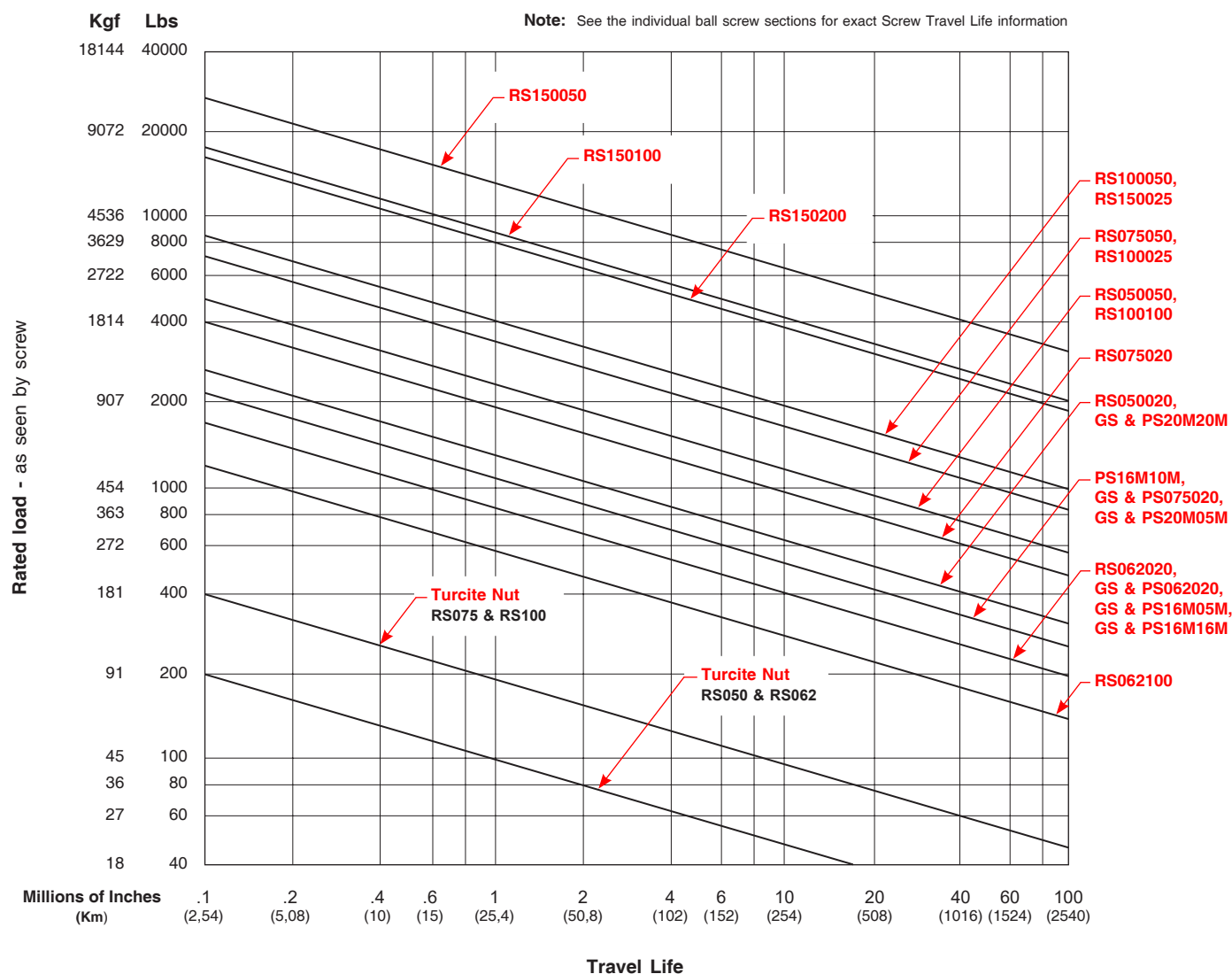
μ = coefficient of friction for linear bearing system (0.01 for typical linear rail & bearing systems)

Vertical Application

$$\text{Applied Axial Load (as seen by lead screw)} = \text{Load Weight}$$

Note: See the individual ball screw sections for exact Screw Travel Life information

Travel Life

Maximum Speed (Critical Speed)

The maximum rotational speed of a ball screw assembly (RPM's) depends on the diameter of the screw, the length of the screw, and the support housing configuration. This is the point at which the rotational speed of the ball screw sets up excessive vibration within the assembly. The maximum speed should never be exceeded since it could cause immediate, or premature failure of a ball screw assembly.
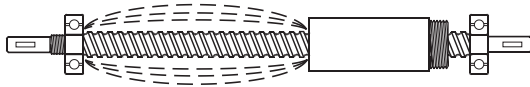
$$MS = S_F \times 3,808,000 \times \frac{d_F}{D^2}$$

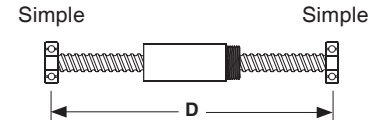**MS** = Maximum screw speed (revolutions per minute).

S$_F$ = Screw support factor (rigidity of support housing).

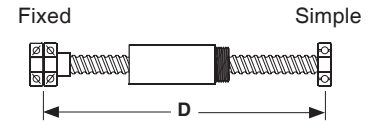**d$_F$** = Diameter factor. $d_F = \dfrac{\text{screw diameter + root diameter}}{2}$

D = Unsupported screw length ("D" distance between bearing supports).

Available Configurations
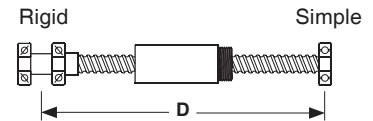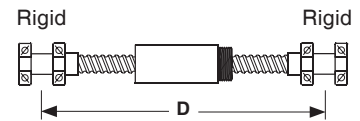
$S_F = 1.00$ Simple — Simple

$S_F = 1.00$ Fixed — Simple

$S_F = 1.47$ Rigid — Simple

$S_F = 2.23$ Rigid — Rigid

Note: See the individual ball screw sections for exact Maximum Speed information

Maximum speed - rev/min of the screw

- 1.500 inch diameter
- 1.000 inch diameter
- 0.750 inch diameter / 20 mm diameter
- 0.625 inch diameter / 16 mm diameter
- 0.500 inch diameter

Simple - Simple	20 (508)	40 (1016)	60 (1524)	80 (2032)	100 (2540)	120 (3048)	140 (3556)
Rigid - Simple	24 (609)	48 (1219)	73 (1854)	97 (2454)	121 (3073)	145 (3683)	
Rigid - Rigid	30 (762)	60 (1524)	90 (2286)	119 (3022)	149 (3784)		

Maximum "D" distance between bearing supports - inches (mm)
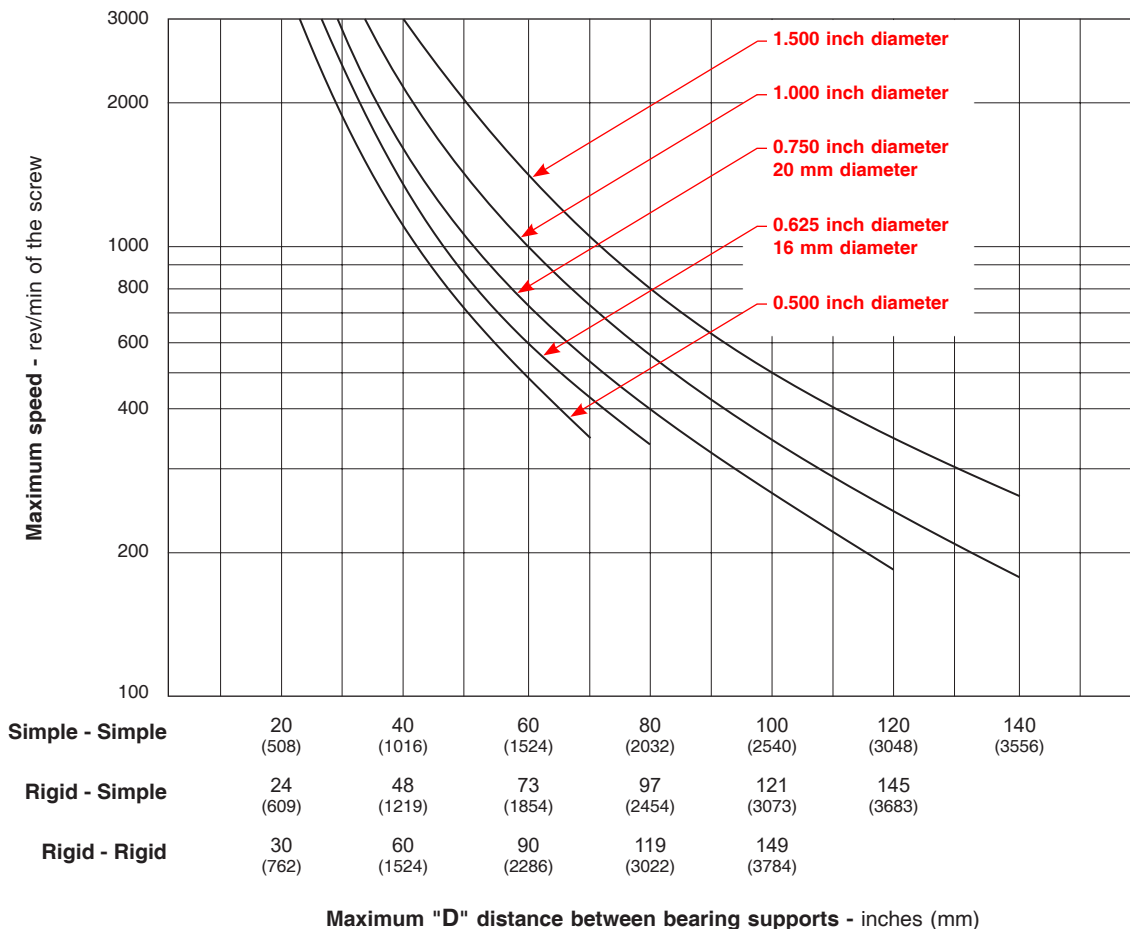
Specifications subject to change without notice

Maximum Compression Load

The load acting upon a nut that would tend to compress or buckle the ball screw shaft. Also referred to as column loading, this rating is effected by the load, support type, screw diameter, and length between the load point and support housing. Normally, a screw shaft also experiences a tension load (a force which attempts to stretch the screw). The maximum tension load of a ball screw assembly is the load rating of the nut. For vertical applications, it is better to configure the ball screw assembly so that the screw is in tension, and not in compression.
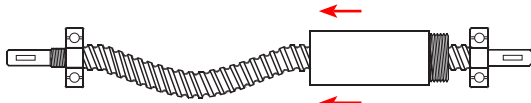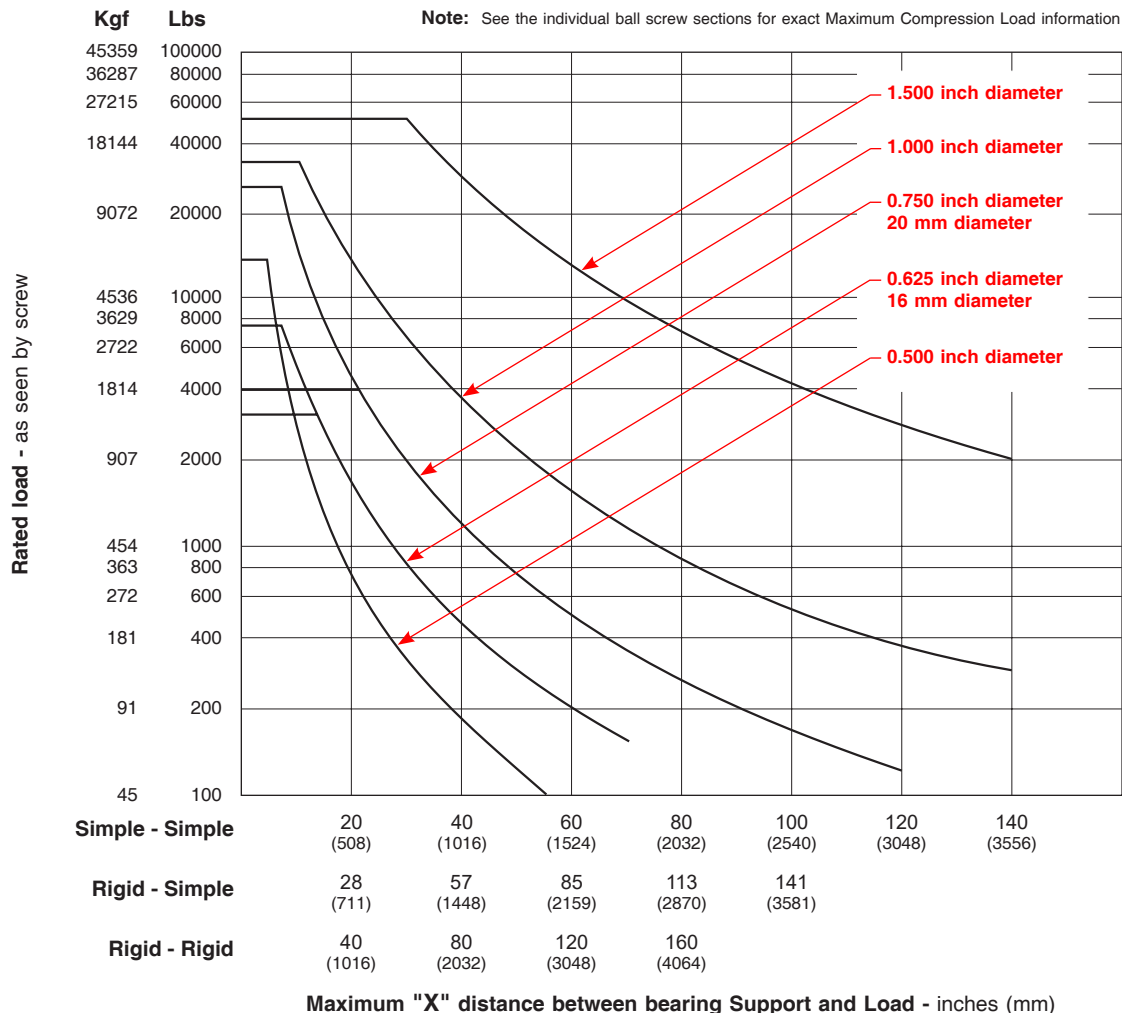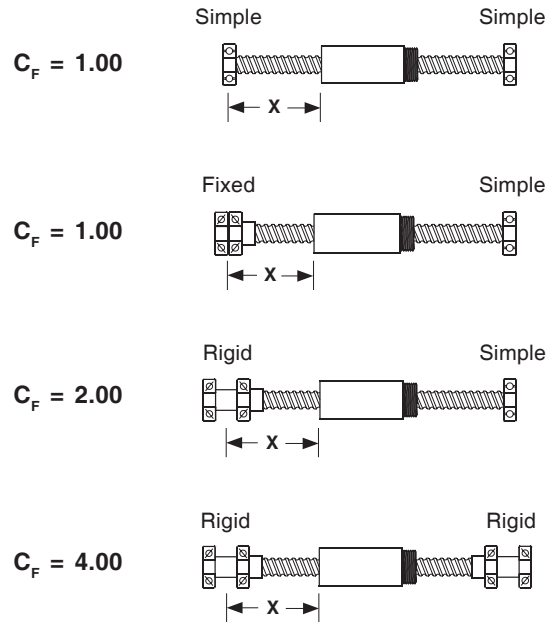
$$MC = C_F \times 11,240,000 \times \frac{d^4}{X^2}$$

MC = Maximum Compression Load.
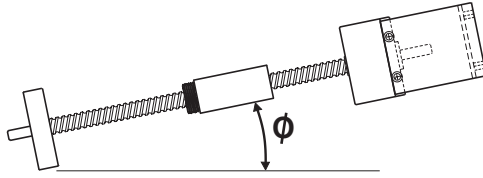
C_F = Screw support factor (rigidity of support housing).

d = Root diameter.

X = Distance between bearing support and load

Available Configurations

Simple — Simple
$C_F = 1.00$

Fixed — Simple
$C_F = 1.00$

Rigid — Simple
$C_F = 2.00$

Rigid — Rigid
$C_F = 4.00$

Note: See the individual ball screw sections for exact Maximum Compression Load information

Rated load - as seen by screw

Kgf	Lbs
45359	100000
36287	80000
27215	60000
18144	40000
9072	20000
4536	10000
3629	8000
2722	6000
1814	4000
907	2000
454	1000
363	800
272	600
181	400
91	200
45	100

1.500 inch diameter
1.000 inch diameter
0.750 inch diameter
20 mm diameter
0.625 inch diameter
16 mm diameter
0.500 inch diameter

Simple - Simple	20 (508)	40 (1016)	60 (1524)	80 (2032)	100 (2540)	120 (3048)	140 (3556)
Rigid - Simple	28 (711)	57 (1448)	85 (2159)	113 (2870)	141 (3581)		
Rigid - Rigid	40 (1016)	80 (2032)	120 (3048)	160 (4064)			

Maximum "X" distance between bearing Support and Load - inches (mm)

Torque Equations - Lead Screws (Linear Motion)

$$T_{Total} = \left[T_{Acc} + T_{Breakaway} + T_{Friction} + T_{Gravity} \right] SF \quad \text{(oz-in)}$$

$$T_{Acc} = \frac{1}{386} \left[\frac{J_{Load}}{e} + J_{LS} + J_{Motor} \right] \frac{\omega}{t_a} \quad \text{(oz-in)}$$

$$J_{Load} = \frac{d^2 (W_{Load} + W_{Other})}{(2\pi)^2} \frac{(16 \text{ oz})}{lb} \quad \text{(oz-in}^2\text{)}$$

$$J_{LS} = \frac{\pi \rho L R^4}{2} \quad \text{(oz-in}^2\text{)}$$

$$J_{Motor} = \text{See Motor Data (\textit{not included in this catalog})} \quad \text{(oz-in}^2\text{)}$$

$$\omega = \frac{2\pi V_M}{d} \quad \text{(rad/sec)}$$

$$T_{Breakaway} = \text{See values in individual screw technical sections} \quad \text{(oz-in)}$$

$$T_{Friction} = \frac{d\, F_T\, \text{Cos}\, \phi}{2\pi e} \frac{(16 \text{ oz})}{lb} \quad \text{(oz-in)}$$

$$F_T = \mu (W_{Load} + W_{Other}) \quad \text{(lbs)}$$

$$T_{Gravity} = \frac{d (W_{Load} + W_{Other}) \, \text{Sin}\, \phi}{2\pi e} \frac{(16 \text{ oz})}{lb} \quad \text{(oz-in)}$$

Terms

C_T	= created thrust force (lbs)
d	= lead of screw (in/rev)
e	= screw efficiency (90% =.9)
F_T	= total frictional force (lbs)
J_{Load}	= load inertia (oz-in^2)
J_{LS}	= lead screw inertia (oz-in^2)
J_{Motor}	= motor inertia (oz-in^2)
L	= lead screw length (in)
ϕ	= angle of load from horizontal (degrees)
ρ	= density of steel screw (4.48 oz/in^3)
R	= radius of lead screw (in)
SF	= safety factor (see note #3)
t_a	= acceleration time (sec)
T_{Acc}	= required torque to accel the load (oz-in)
$T_{Breakaway}$	= breakaway torque (oz-in)
$T_{Friction}$	= required torque to overcome system friction (oz-in)
$T_{Gravity}$	= required torque to overcome gravity (oz-in)
T_{Total}	= required torque to move the load (oz-in)
μ	= coefficient of friction for linear bearing system (.01)
V_M	= max linear velocity (in/sec)
ω	= angular velocity (rad/sec)
W_{Load}	= weight of load (lbs)
W_{Other}	= weight of nut or weight of mounting hardware (lbs)
π	= 3.1416

Notes:

1) T_{Total} is the maximum torque required from a motor during a move. This usually occurs during the acceleration portion of a move profile for horizontal applications and an upward move for vertical applications. During the deceleration portion of a move profile, $T_{Friction}$ and $T_{Breakaway}$ are subtractions from T_{Total}. For horizontal applications $T_{Gravity}$ has a zero value.

2) The factor 386 in the denominator for the T_{Acc} equation represents acceleration due to gravity (386 in/sec^2 or 32.2 ft/sec^2) and converts inertia from units of oz-in^2 to oz-in-sec^2.

3) The safety factor (SF) should be between 1.4 to 1.6 for step motor systems and between 1.1 to 1.2 for servo motor systems.

Thrust Force Equation

$$C_T = \frac{2\pi e (T_{Total})}{d} \frac{lb}{(16 \text{ oz})} \quad \text{(lbs)}$$

xS   062   020   -   x   -   Sx   A   -   Nx   -   Wx   -   Fx   -   Mxx   -   Cxxx   -   Exx   -   Bxx   -   Lxxx.xxx

Series - (xS)

There are three different ball screw types available. They are the Rolled Screw (RS), Precision Screw (PS), and the Ground Screw (GS).

Screw Diameter - (062)

These three digits define the diameter of the ball screw. For English screws, the number denotes the diameter in inches (x.xx). For Metric screws, the number denotes the diameter in millimeters (xxM).

Screw Lead - (020)

These three digits define the screw lead. For English screws, the number denotes the lead in inches (x.xx). For Metric screws, the number denotes the lead in millimeters (xxM).

Internal Order Code - (x)

This digit is only required for the ground ball screw series (GS). It denotes if the screw thread length is short (1) or long (2). The appropriate series will give the information that constitutes what is a short or long length.

Support Configurations - (Sx)

Five standard choices are available which define the type of ball screw support housings. They are Simple-Simple (S1), Fixed(LT)-Simple (S2), Fixed(HT)-Simple (S3), Rigid-Simple (S4), and Rigid-Rigid (S5). Each screw series and screw diameter lists the technical data for these support configurations.

Support Material - (A)

The end support material can either be made of Aluminum or Steel. Add an A to the part number for Aluminum or add nothing to the part number for Steel.

Nut Type - (Nx)

Three different nut styles are available for a ball screw assembly. They are a non-preloaded ball nut, a preloaded ball nut, or a non-preloaded Turcite nut. The RS series has all three options available through the 1.000 inch diameter screw. The 1.500 inch diameter RS series and the PS series only have the non-preloaded ball nut and preloaded ball nut options. The GS series only has the preloaded ball nut options. Also, the threads on the ball nut can face to the right of the assembly, or to the left of the assembly with respect to the drive end housing.

Left Facing Thread (LFT)   Right Facing Thread (RFT)
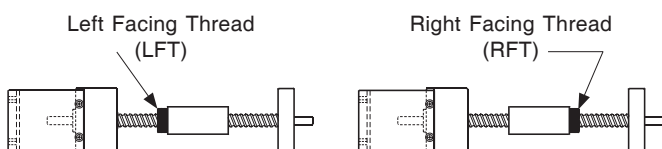
Nut Wipers - (Wx)

This indicates if the brush type wipers on the nut assembly are required (W1). This option is only available for the ball nut versions of the RS series.

Nut Flange Type - (Fx)

There are three available nut flanges. They are a round flange (F1), a vertical bracket (F2 or F3), and a "L" bracket (F4 or F5). If selected, these brackets are premounted to the nut on the ball screw assembly. The vertical bracket and "L" bracket options are available with either an English or Metric interface for mounting of the user load. Since the round flange has thru holes, the user can use either English or Metric nuts & bolts.

Motor Mount - (Mxx)

The Fixed and Rigid housings of each screw series are designed to accept NEMA 23, NEMA 34, or NEMA 42 motor mount brackets with either an English or Metric mounting interface for the user motor. These housings can also accept NEMA 23, NEMA 34, or NEMA 42 motor wrap packages. No Simple housing is designed to accept a motor mount option. Custom motor mount packages are available upon request. There is a Hand Crank option for the smaller diameter screws within each screw series.

Coupling Type - (Cxxx)

Three different styles of motor couplings are available. They are the C type, H type, and G type. Each of these styles have different diameters, lengths, torque ratings, and wind-up values. For a given screw series and screw diameter, only certain sizes within each coupling style is available. This is due to the diameter of the ball screw extension from the drive housing and the available motor mount bracket sizes.

Rotary Encoder - (Exx)

There are three different resolutions for the incremental rotary encoder which can be mounted to the support housing opposite the motor driven housing. They are a 500, 1000, and 1270 line per revolution encoders. These shaftless encoders are first mounted to an adapter plate, and then mounted to either the Simple, Fixed, or Rigid housing.

Power-off Brake - (Bxx)

There are two different input power requirements (24 or 90 VDC) for the power-off brake which can be mounted to the support housing that is opposite the motor driven housing. These shaftless brakes are first mounted to an adapter plate, and then mounted to the Simple, Fixed, or Rigid housing.

Thread Length - (Lxxx.xxx)

This value specifies the length in inches (xxx.xxx) of the screw thread between the inside edges of the two support housings. Actual nut travel will be this value minus the overall nut length selected for the assembly.

Backlash

Preloaded and non-preloaded ball screw nut assemblies are available for use in the RS and PS series. The GS series is only available with a preloaded nut. A preloaded nut ensures there will be no ball screw movement, without nut movement, when the ball screw direction of rotation is changed. A non-preloaded nut will have some backlash, ball screw movement before nut movement, when the ball screw direction of rotation is changed in horizontal applications. In vertical applications (with no reversing load), a non-preloaded nut will not exhibit any backlash, as gravity is always producing a force in the downward direction against the ball screw nut. *Using a preloaded nut always eliminates backlash, therefore the unidirectional & bidirectional repeatability values will always be the same*.

Backlash →
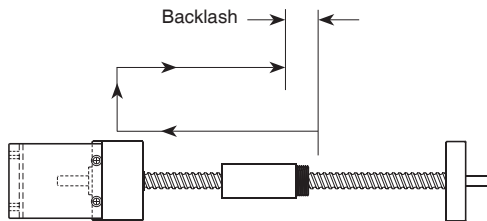
Backdriving

The ability of the ball nut to rotate the ball screw when an external force is applied to the nut. Typically happens in vertical applications where the applied load is great enough to overcome the ball nut's frictional forces.

Ball Diameter

The nominal outer diameter of the steel balls which circulate through the ball nut as it travels on the ball screw threads. These balls carry the load applied to the ball screw through the ball nut.

Base Mounting

Allows mounting of a support housing to a base plate.

Breakaway Torque

The torque required to start linear nut motion. It consists of the bearing support configuration, bearing support end seal friction, preload force of the support housing (if any), and the preload force of the ball screw nut assembly.

Diameter

(Screw diameter or major diameter) The nominal outer diameter of the ball screw thread. Measured in inches for English model screws, and millimeters for Metric model screws.

(Root diameter or minor diameter) The diameter of the screw measured at the bottom of the ball threads on the screw. Measured in inches for English model screws, and millimeters for Metric model screws.

Dynamic Load

The maximum load weight, as seen by the ball nut, which will give the rated life of the ball nut. The rated life of a ball screw assembly is measured in inches of travel under a specified load. Ball nut life is dependent upon preloaded force, load weight and load orientation.

Face Mounting

Allows mounting of a support housing to a wall, end plate, frame, or gusset and does not require a base surface.

Hardness

The property of a material which has the ability to abrade or indent one another. Ball screws are hardened to resist permanent indentation. Typically a Rockwell "C" measurement is used to obtain a numerical value based on a metals resistance to permanent indentation. The higher the value, the greater the materials resistance to indentation.

Lead

For a ball screw, the linear travel of the ball screw nut assembly, for every one full (360 degree) rotation of the screw. Not the same as pitch. Lead is the inverse of pitch (i.e. 0.200 inch lead = 5 pitch).

Lead Error

The error in lead length per foot, or 300 mm, as compared to the basic lead specified. Lead error is cumulative, and is based upon the manufacturing processes of the individual ball screw types.

Lubrication

Ball screw assemblies require a small amount of grease or oil for proper, long term operation. Lubrication will decrease system wear and the potential for oxidation of the ball screw surface. For most applications, a medium to heavy oil, light grease, or silicone based lubricant is recommended. The many built-in pockets within the ball screw nut allow the adhesive properties of these lubricants to be stored for extended periods of time.

For high speed applications, a light grease is recommended, while the ball screw should NEVER be operated dry for any length of time. For some low speed and lightly loaded applications, a ball screw assembly can typically be operated without lubrication, but for the most part, this is not recommended. Use of WD-40, or other cleaning solvents, should strictly be avoided, as they can cause damage to the ball screw nut.

All ball screw assemblies are shipped with grease applied to the ball screw & ball nut. It is recommended that lubricant be applied to the ball screw and linear rails prior to operation. Also, periodic re-lubrication helps assure that the rated life of the ball screw assembly is attained.
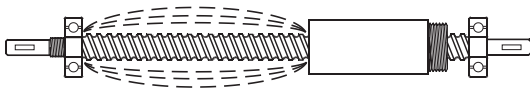
All support housings do NOT require lubrication. The housings or bearings are internally lubricated for life, and sealed to prevent outside contamination from getting in.

Maximum Acceleration Rate

This rating is the maximum acceleration that a ball nut or support housing can handle on a regular basis. It is also limited by the maximum thrust force a particular nut or support housing can sustain. For example, if the maximum acceleration for a ball screw assembly is 772 inches/sec^2, but a specific load accelerated at 100 inches/sec^2 produces the maximum thrust force for the ball screw or support housing - then the maximum acceleration rate for that load is 100 inches/sec^2. (F = MA).

Maximum Speed

The maximum rotational speed of a ball screw assembly (RPM's) depends on the diameter of the screw, the length of the screw, and the support housing configuration. This is the point at which the rotational speed of the ball screw sets up excessive vibration within the assembly. The maximum speed should never be exceeded since it could cause immediate, or premature failure of a ball screw assembly.

Maximum Compression Load

The load acting upon a nut that would tend to compress or buckle the ball screw shaft. Also referred to as column loading. This rating is effected by the load, support type, screw diameter, and length between the load point and support housing.
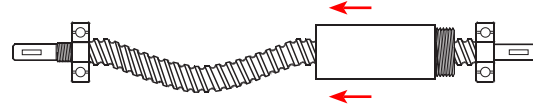
Number of Circuits

The circuit or "return tube" on a ball nut provides for distributing the load carrying balls onto the screw thread as they recirculate through the ball nut. The return tubes can be either external or internal.

Non-preloaded Nut

A single ball nut, or Turcite nut, that produces backlash when the screw is rotated back and forth.

Preloaded Nut

A single, or double, ball nut that eliminates backlash when the screw is rotated back and forth. The preloading can be accomplished internally, or externally. The internal method uses oversized load carrying balls in the nut and also requires that the nut be "matched" to an individual screw. The external method loads two single nuts against each other with a locking spanner nut and belville spring.

Repeatability

How accurate a ball screw's nut can (via either unidirectional or bidirectional moves) return to a known, previously traveled location for a given load weight, load speed, and load acceleration. The ball screw nut type (preloaded or non-preloaded) directly affects this value. Other factors besides the ball screw assembly, that contribute to the overall repeatability are the linear bearing system, mounting surface, and overall alignment of the bearings, rails, and screw assembly.

For horizontal applications, the bidirectional repeatability value is determined by adding the backlash in the lead screw nut assembly to the unidirectional repeatability value. For vertical applications (with no reverse load), the bidirectional and unidirectional repeatability will be the same, as gravity eliminates backlash in non-preloaded nut assemblies. Using a preloaded nut assembly always eliminates backlash. Therefore, the unidirectional & bidirectional repeatability values will always be the same.

Horizontal Applications - Unidirectional Repeatability

Travel to the desired location is always from the same direction
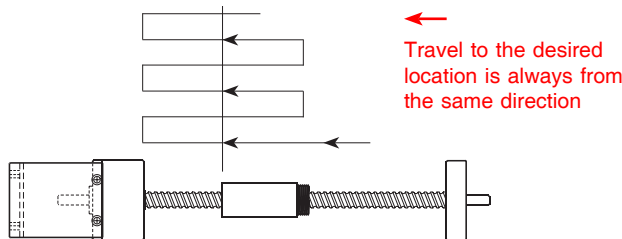
Horizontal Applications - Bidirectional Repeatability

(Unidirectional Repeatability + Backlash)

**Backlash**

Travel to the desired location is from either direction
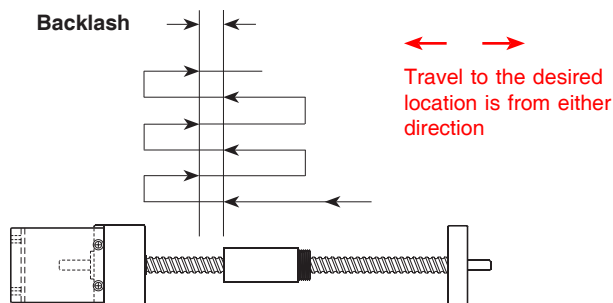
Repeatability - continued

Vertical Applications (No reverse load)

Bidirectional Repeatability	=	Unidirectional Repeatability

Reverse Load

An upward force acting on a nut; such as when inserting a part (moving in a downward direction) into another part.

Reverse Load

Travel to the desired location is from either direction
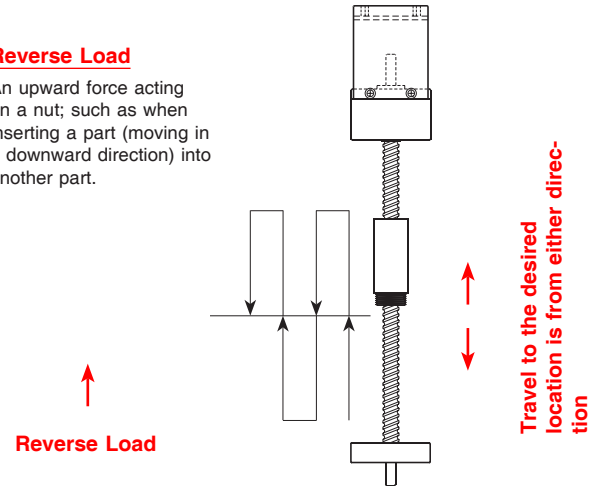
Right Hand Thread

The direction of the threads on the screw, which cause the nut to travel away from the end viewed, when the screw is rotated in a clockwise direction.

Screw Efficiency

This defines the "loss of energy" when attempting to move the ball nut by rotating the ball screw. Used for calculating torques required to move a specified load weight. Ball nuts typically have an efficiency of 90%, while Turcite nuts typically have an efficiency of 60%.

Screw Maximum Length

This is the overall length "end to end" of the screw stock available for each screw series and screw diameter. Does not specify what the maximum travel, or thread length is.
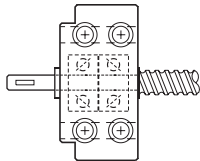
Static Load

The maximum permissible load weight, or external force, which can be applied to the nut of the ball screw assembly, with the ball screw at rest.
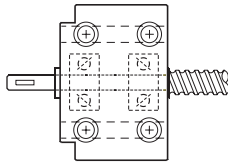
Support Housings

Simple - A single bearing used to support the end of a ball screw.
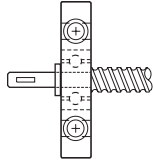
Fixed - Two (2) back to back bearings used to eliminate end play when supporting the end of a ball screw.

Rigid - Two (2) spaced apart bearings used to eliminate end play and to provide added rigidity when supporting the end of a ball screw.


Support Housing Thrust Load Capacity

The maximum permissible axial force which can be applied to the end bearing support housing. The axial force is generated by the movement of the ball screw. The support housing life is dependent upon the number of screw revolutions and axial force applied.
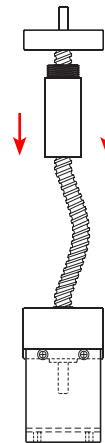
Tension Loading

The load acting upon a nut that would tend to stretch the ball screw shaft. The maximum tension load of a ball screw assembly is the load rating of the nut. For vertical applications, it is better to configure the ball screw assembly so that the screw is in tension and not in compression.
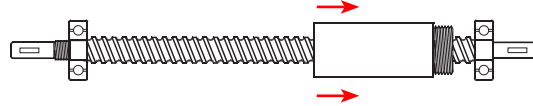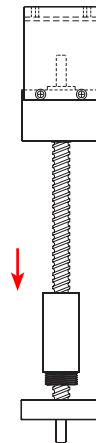

Vertical Applications

Compression   Tension

Travel Length

The total possible travel of the nut for a given ball screw configuration. The ball screw assembly thread length minus the nut length will determine the possible nut travel length.

Thread Length

The total length of the screw thread between the two support housings for a given configuration. The ball screw assembly thread length minus the nut length will determine the possible nut travel length.

Turcite Nut

This polymer material has characteristics similar to Teflon. There are no recirculating balls within the nut assembly. It is resistant to corrosion, but has higher friction than a ball nut, thus creating more heat and wear.