Leadscrew BASICS

Leadscrews for linear motion come in a variety of styles, each with its own benefits and downside.

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The Acme or solid screw uses a resin or bronze nut which creates sliding contact with the leadscrew. In metric design, this is referred to as a trapezoidal screw.

In a ball screw, a recirculating bearing nut rolls along the ball screw's threads.

In a roller screw, several threaded rollers are assembled in a planetary arrangement around the threaded shaft.

Acme screw

BENEFITS	LIMITATIONS
Lower in cost	Solid nut can wear and affect positioning
Quieter	Lower efficiencies require higher input torque
May reduce or remove back-driving	Unpredictable service life
Good for slow speeds and low duty cycles	External factors such as the environment can affect screw life

Ball screw

BENEFITS	LIMITATIONS
More thrust than a solid nut	Ball nut can be easily back driven depending on load
Longer, more predictable life	Higher initial cost than Acme screw
Increased efficiency (70 to 95%)	Noisier than Acme screws
Low backlash (typically 0.0001 to 0.005 in.)	
Good for high-duty cycles, and high thrusts and speeds	

Roller screw

BENEFITS	LIMITATIONS
High thrust capabilities	Highest cost of three screw types
Extremely long life	In vertical applications, screw can be back-driven or free-fall with loss of motor torque
High speed and accelerations	Nut assembly has large outside diameter

Leadscrew assemblies or drives are widely used to generate linear motion. And you can get this motion by turning either the screw or the nut. Three primary types of screws are used for linear-motion actuators: Acme, ball, and roller. The differences are in thread shape and the design and operation of the matching nut. But which type of screw best suits your application? Here's a concise look at all three.

Acme screws use strong threads with generally trapezoidal teeth which are usually rolled onto a steel shaft or leadscrew. As the shaft turns, its threads transmit linear force to the nut. Efficiency is determined by nut material, leadscrew, and lubrication, and is relatively low, ranging from 20 to 40%. This level of efficiency can prevent loads or external forces from back-driving the assembly, which can be an advantage. However, inherent energy losses mean Acme screws need more motor torque compared to other screw types.

Common nut materials include self-lubricating plastics, polymers, and metals such as brass or bronze. Nonmetallic materials generally have higher efficiencies due to lower coefficients of friction and often do not require lubrication. Metal nuts such as bronze can handle higher working loads but may require lubrication, which can lead to contamination.

Wear characteristics of Acme nuts depend on nut material, environment, lubrication, and the application. The amount and rate of wear is generally not easy to predict due to the large number of variables. But to compensate for wear, some manufacturers build Acme nuts out of two halves biased to each other with a spring. Nuts using this design are commonly referred to as "antibacklash" or "zero-backlash." It is important to note that these nuts may add friction.

Acme screws are available in a variety of diameters and leads. Metric versions, commonly called trapezoidal screws, are also available. Although English and metric designs have similar tooth shapes, they are not interchangeable due to a 0.5° difference in flank angles.

Ball screws use circular or ogival (Gothic arch) threads. The nut has the same thread, letting ball bearings fit between the two grooves to transmit force and relative motion. Efficiencies range from 70 to 95%.

The bearings roll and recirculate through one or several circuits in the nut as the screw or nut rotates and one or the other moves. Ball-screw nuts differ in the number of ball-bearing circuits and how they control recirculation paths. Ball-bearing path is critical in determining an assembly's maximum speed. Alternative designs, such as internal paths or end returns, offer minor advantages such as higher speeds and less noise.

BALL-SCREW GRADE	LEAD ACCURACY
1	6 µm/300 mm (about 0.0002 in./ft)
3	12 µm/300 mm (about 0.0005 in./ft)
5	23 µm/300 mm (about 0.0010 in./ft)
7	52 µm/300 mm (about 0.0020 in./ft)
10	210 µm/300 mm (about 0.0080 in./ft)

Ball screws are available in a variety of diameters, leads, and accuracies with both metric and English leads. A grade system regulated by ISO-3408 classifies ball-screw lead accuracies.

The grade can help determine the lead accuracy of an assembly. These grades do not factor in any backlash specifications. However, Grade 1 and 3 screws are almost always ground for precision. Grinding, while precise, is also time consuming and more costly. Rolling is the way most other grades are made. Backlash in a ball screw can be

Screw terminology

Accuracy: The ability of a system to hit a targeted linear position.

Back-driving force: The linear force or thrust needed to rotate the screw or nut in a reverse fashion. For example, gravity in a vertical system may be able to back-drive a screw drive and create torque and/or linear motion.

Backlash: The amount of free movement between a screw and nut.

Critical speed: The rotational velocity of a screw at which vibrations develop due to the shaft's natural harmonic frequency. This is also commonly referred to as "screw whip" and depends on the diameter and length of screw between supports.

Duty cycle: A percentage rating for an application that compares the amount of running time to rest time. An application that runs continuously would have a 100% duty cycle; as an application that runs for 15 sec then rests for 45 sec before completing another cycle would have a 25% duty cycle.

Dynamic load rating: A value used in life calculations for screw and nut assemblies. It is also the maximum thrust load a screw and nut assembly can transmit.

Lead: Linear distance of travel generated by one revolution of the screw or nut. It's measured in units/revolution such as inch/revolution.

Lead accuracy: The possible variation in travel distance within a standard length of screw. Measured in unit/units such as inch/foot.

Pitch: Linear distance between threads. Pitch is not necessarily equal to the screw's lead when a screw has multiple thread starts. Measured in units such as inches.

Preload: Amount of tension or preapplied force set into a bearing to remove looseness (play) in mechanical assemblies. This applies to screw and nut combinations, as well as linear bearings. For ball screws, this reduces axial and radial play and increases stiffness and repeatability.

Repeatability: The ability of a system to go to the same location in repeated attempts.

Rolling: A manufacturing process that forms threads on screw shafts by using pressure. Rotating dies containing desired thread profile are pressed against a blank shaft to displace material and create thread forms.

Static-load rating: The maximum load that may be applied to a stationary screw and nut assembly without damaging it.

Turns: The number of revolutions needed to travel a given distance (For example, eight turns/inch).

adjusted in a number of ways. A common method is to load each circuit with balls of a diameter that gives the desired backlash. This method may also be used to preload a system. Another preloading technique is to install two nuts biased against one another and locked into position. Having two nuts on a single ball screw will not double the force capability of the system.

Roller (planetary) screw threads are triangular and transmit force through a matched set of threaded rollers in the nut. Rollers rotate while contacting the screw's threads. The nut's rollers have significant surface contact with the screw, letting them transmit high forces while giving the assembly a longer life compared with ball screws of similar diameter.

Ball screws and roller screws use rolling motion rather than sliding like Acme screws. This means ball screws are more efficient than Acme screws.

Roller screws fall within the ISO-3408 grading system, so they share lead-accuracy considerations. Roller screws are most commonly ground to provide continuous contact area, smooth motion, and high thrust outputs. However, some roller screws are precision rolled to lower costs, with some possible sacrifice in performance. **MD**