

Standard Positioning Tables

LINTECH manufactures a wide range of standard belt & screw driven linear positioning tables, along with standard rotary positioning tables that operate in a wide range of applications. We have been manufacturing standard positioning tables for over thirty years. We pride ourselves on providing a wide range of options available for each of the different table series in this catalog. This allows the machine designer an opportunity to select a standard positioning table instead of what might be a custom system. Each of our table series is broken down into individual catalog sections. Each section has all the pertinent data for that table series located within it.

Overview - Screw Driven Linear Positioning Tables

Table Series	Dynamic Load Capacity lbs (kg)	Linear Bearing Type	Flatness & Straightness inch/inch (microns/25 mm)	Drive Screws	Unidirectional Repeatability (ground ball) inches (microns)	Maximum Axial Load (Thrust) Load lbs (kg)	Travel Lengths inches (mm)	Height inches (mm)	Width inches (mm)
130	200 (90)	Recirculating square rail	< 0.00013 (3,30)	Acme Rolled Ball Precision Ball Ground Ball	+/- 0.0001 (2,5)	1,355 (615)	2 to 60 (50 to 1520)	2.375 (60,33)	2.875 (73,03)
100	3,100 (1406)	Recirculating square rail	< 0.00013 (3,30)	Acme Rolled Ball Precision Ball Ground Ball	+/- 0.0001 (2,5)	1,355 (615)	2 to 60 (50 to 1520)	2.375 (60,33)	3.500 (88,90)
110	3,100 (1406)	Recirculating square rail	< 0.00013 (3,30)	Acme Rolled Ball Precision Ball Ground Ball	+/- 0.0001 (2,5)	1,355 (615)	1 to 45 (25 to 1155)	2.375 (60,33)	5.250 (133,35)
90	3,300 (1496)	Recirculating round rail	< 0.00016 (4,06)	Acme Rolled Ball Precision Ball Ground Ball	+/- 0.0002 (5)	1,725 (782)	6 to 60 (150 to 1520)	2.930 (74,42)	8.000 (203,20)
150	3,800 (1724)	Recirculating square rail	< 0.00004 (1,02)	Acme Rolled Ball Precision Ball Ground Ball	+/- 0.0001 (2,5)	1,725 (782)	6 to 62 (150 to 1570)	2.625 (66,67)	6.750 (171,45)
160	5,600 (2540)	Recirculating square rail	< 0.00016 (4,06)	Acme Rolled Ball Precision Ball Ground Ball	+/- 0.0002 (5)	1,725 (782)	6 to 60 (150 to 1520)	2.953 (75,00)	5.500 (139,70)
170	5,600 (2540)	Recirculating square rail	< 0.00016 (4,06)	Acme Rolled Ball Precision Ball Ground Ball	+/- 0.0002 (5)	1,725 (782)	6 to 60 (150 to 1520)	2.953 (75,00)	6.000 (152,40)
200	8,800 (3992)	Recirculating square rail	< 0.00004 (1,02)	Acme Rolled Ball Precision Ball Ground Ball	+/- 0.0001 (2,5)	2,110 (957)	6 to 55 (150 to 1395)	3.750 (95,25)	8.500 (215,90)
250	16,600 (7530)	Recirculating square rail	< 0.00004 (1,02)	Acme Rolled Ball Precision Ball Ground Ball	+/- 0.0001 (2,5)	3,630 (1646)	6 to 56 (150 to 1420)	4.875 (123,82)	10.000 (254,00)

Overview - Belt Driven Linear Positioning Tables

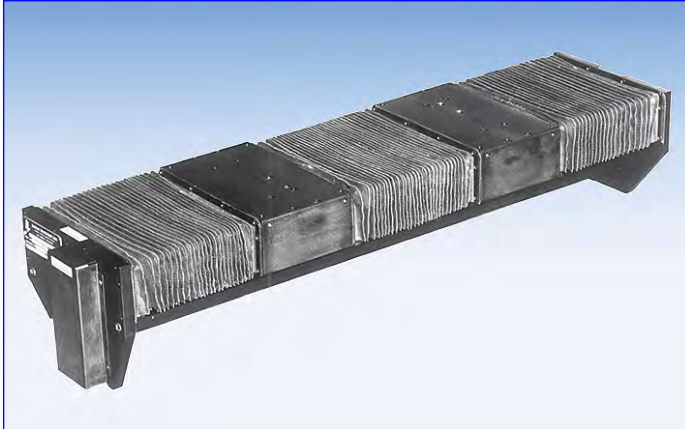
Table Series	Dynamic Load Capacity lbs (kg)	Linear Bearing Type	Unidirectional Repeatability inches (mm)	Drive Belt Width	Maximum Speed inches/sec (m/sec)	Maximum Axial (Thrust) Load lbs (kg)	Travel Lengths inches (mm)	Height inches (mm)	Width inches (mm)
120	3,100 (1406)	Recirculating square rail	+/- 0.001 (0,025)	16 mm	118 (3)	115 (52)	4 to 120 (100 to 3045)	3.000 (76,20)	3.500 (88,90)
180	5,600 (2540)	Recirculating square rail	+/- 0.001 (0,025)	32 mm	118 (3)	230 (104)	3 to 108 (94 to 2740)	2.953 (75,00)	6.000 (152,40)
550	10,320 (4681)	Recirculating square rail	+/- 0.001 (0,025)	50 mm	197 (5)	475 (215)	12 to 360 (300 to 9144)	3.937 (100,00)	3.150 (80,00)

Overview - Rotary Positioning Tables

Table Series	Dynamic Load Capacity lbs (kg)	Rotary Bearing Type	Drive Type	Ratios	Table Top Diameters inches (mm)	Through Hole inches (mm)	Accuracy arc-sec	Unidirectional Repeatability arc-sec
300	225 (102)	angular contact	worm gear	45:1 90:1 180:1	6 (152) 8 (203) 10 (254) 12 (305)	0.750 (19,05)	< 150	< 10
400	1,000 (453)	4 point contact	worm gear	30:1 180:1 90:1 270:1 360:1	5.48 (139,2)	4.500 (114,30)	< 180	< 12

Custom Positioning Systems

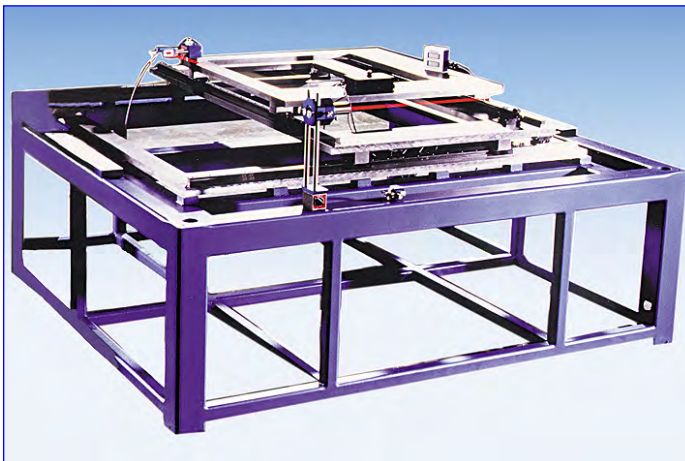
Sometimes a standard positioning system is not the right choice for a particular motion control application. Nor is it possible, or practical, to have the system built in house by your own design team. Let *LINTECH* take a look at your special requirements. *LINTECH* has been designing and building custom positioning systems for over 30 years. We can use our many years of experience to help you select the right approach to a unique motion control problem. Fill out our application guide on page A-45 and fax it to us or visit our website. We stand ready to assist you.



Two carriages (individually driven by two motors) on the same base for automated part assembly process

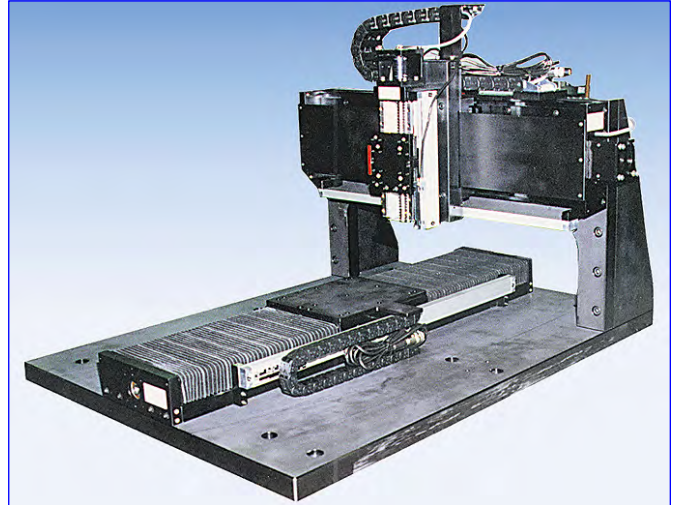


X-Y-Z automated assembly system with aluminum support structure



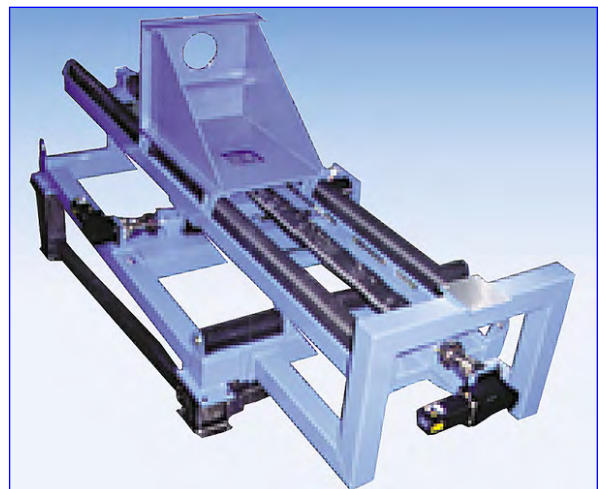
X-Y open frame inspection station with steel support structure

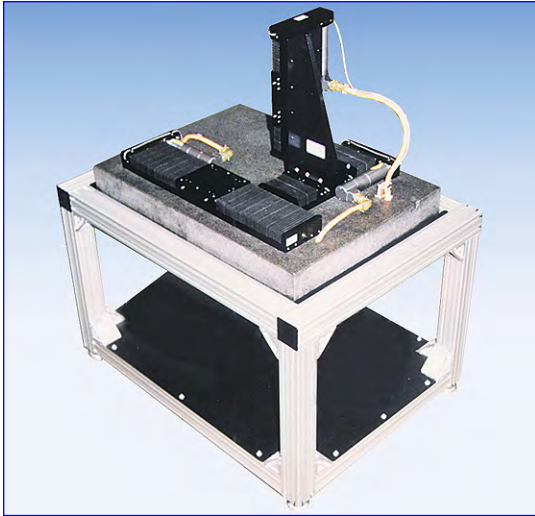
X-Z vision inspection station mounted on steel sub plate



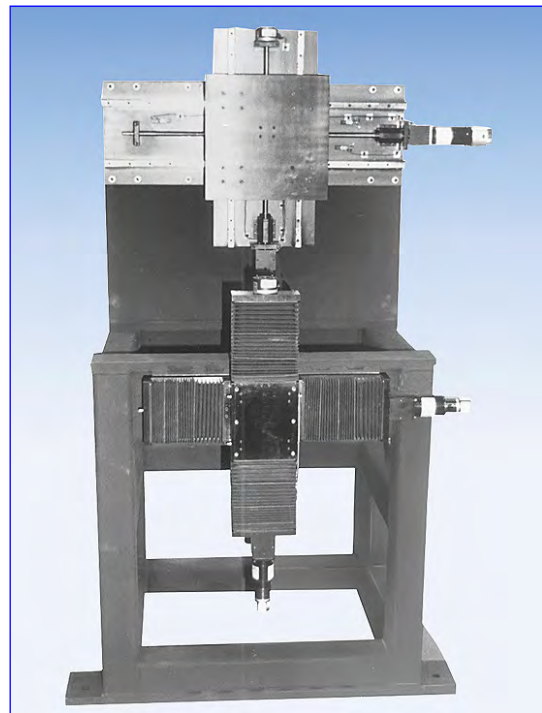
Belt driven long travel X-Y-Z inspection station with aluminum support structure

X-Y machine assembly process with steel support structure

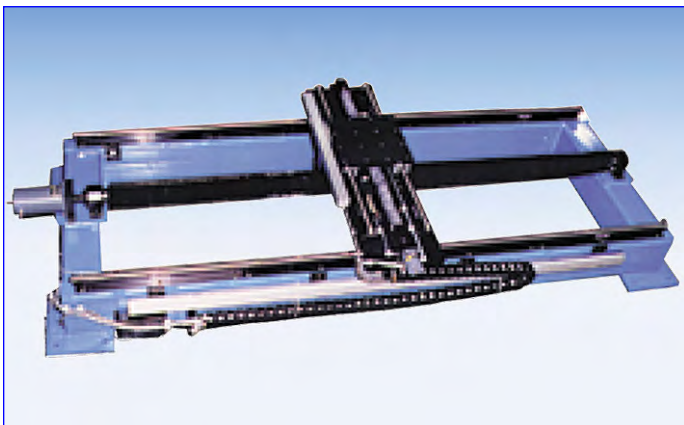




X-Y-Z high accuracy
chemical coating process
mounted on granite & aluminum support structure

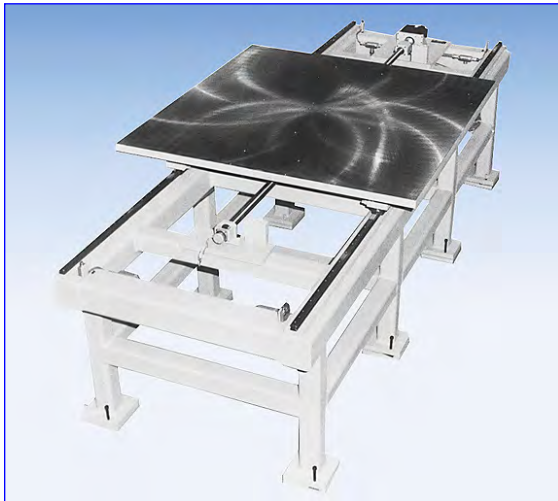
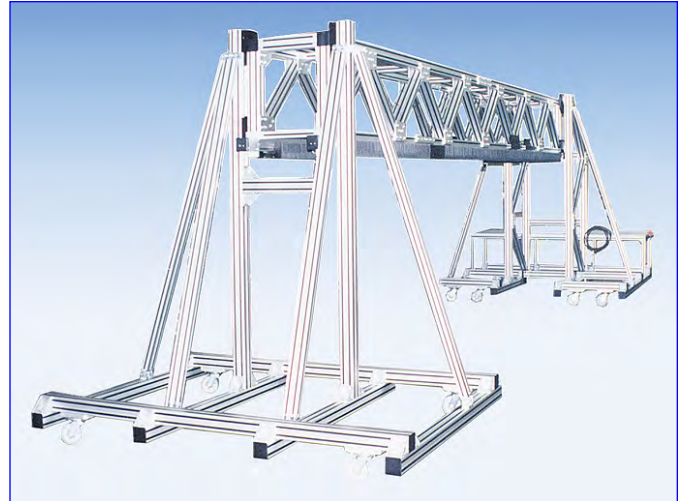


Two individual
X-Y axes for laser cutting
process supported by steel structure

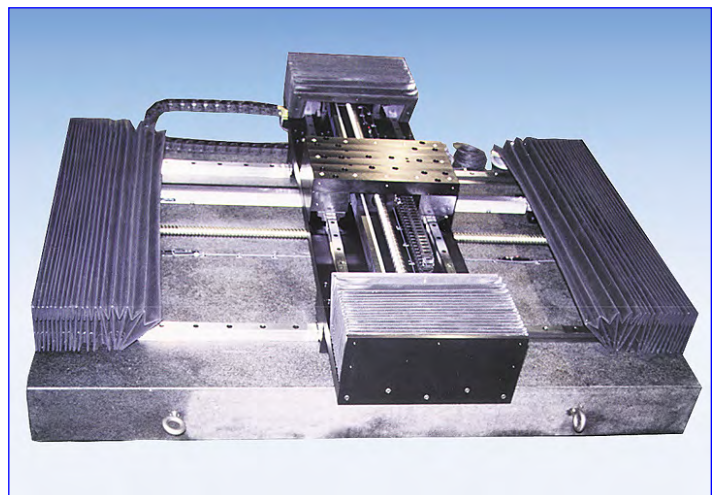


X-Y axis
water jet cutting process
with open frame steel support structure

X-Y belt driven
infrared inspection station
supported by movable aluminum structure



X axis machining station
with steel support structure



X-Y laser marking assembly
with granite surface support structure

What kind of Positioning System do I need?

There are several different mechanical devices that can be chosen for a given motion control positioning application. These devices can have differences in the load carrying components, drive mechanisms, support structures, physical construction, along with numerous other options. All these parameters lead into a mechanical device that has certain performance specifications. Before selecting a mechanical device, one needs to understand these performance specifications, along with the pro's & con's of each mechanical device & its options.

Linear Positioning Systems consist of many different types of mechanical positioning devices. We are limiting our discussion here to electromechanical devices. Some of these devices are more suited to generate thrust forces, while other devices are more suited to position a load accurately & repeatedly.

Actuators (electric cylinders) are mainly thrust producing devices. These devices use either an acme or ball screw as the driving mechanism with the screw mounted in a rigid-free arrangement. Any moment or side load needs to be properly supported by a separate mechanical structure. From a positioning standpoint these actuators are neither highly accurate, nor repeatable.

Rodless Actuators are also mainly thrust producing devices. However, because of their design, they can be used in some positioning applications. These devices use either an acme screw, ball screw, or a belt as the driving mechanism. These devices have both ends of the driving mechanism supported, therefore longer travels and higher speeds are attainable. The carriage for the user load is mounted to some kind of linear bearing system, thus allowing for small side loads. Nylon bushings, plastic bearings, rollers, wheels, round or square rails are typically used for the linear bearing system. From a positioning standpoint these devices are not highly accurate, however they can be very repeatable.

Screw Driven Positioning Tables are typically used in applications where accuracy & repeatability are more important than axial thrust forces. The base, carriage, and all critical components are precision machined which contribute to the accuracy and repeatability of the system. These positioning tables use either an acme or ball screw as the driving mechanism. Ball & rod, cross roller, round rail, or square rail linear bearings are used to carry the user load. These linear bearing designs allow the user load to be positioned very accurately & repeatedly.

Belt Driven Positioning Tables are typically used in high speed (and/or long travel) positioning applications where a

screw driven table is not applicable. The belt & pulley drive mechanism, along with either round rail or square rail linear bearings, provide a repeatable, high speed positioning table. These tables provide the same speed capability independent of travel length. Using a high quality belt, pulley, and linear bearing mechanism provides a fairly accurate & repeatable positioning table.

High Accuracy Positioning Tables are typically used in applications where high accuracy and repeatability are very important. All components are machined to very tight tolerances in order to achieve the required accuracy and repeatability. Precision ground acme screws, precision ground ball screws, or brushless linear motors are typically used as the driving mechanisms. Precision ground cross roller, ultra high accuracy square rail, or air bearings are mainly used for the linear bearings. The combination of these precision components produce a very smooth operating table. Granite or a precision machined steel plate is typically used for the table mounting surface. Temperature controlled environment, machine shock absorbers, and high resolution linear encoders are also usually required in order to obtain the system accuracy and repeatability. All this comes at an increase to the overall positioning system cost.

Rotary Positioning Systems consist of mainly three different major designs to choose from. These are mechanical tables, direct drive tables, and rotary positioning tables.

Mechanical (air actuated) rotary tables are inexpensive devices that rotate to a finite number of locations. You typically cannot change their resolution and over time the repeatability can, and usually will change. Load capacities are typically large and these tables are very durable. However, an air source is required to operate the tables.

Direct Driven Rotary Devices have a built in brushless motor that turns the table top. Key benefits include high accuracy and torque in a package that does not have a gear reducer. Thus, there is little concern over mechanical wear of a gear reducer. The key disadvantages include high system cost, a tall table package, and the requirement of using a specific motor control system, one designed for that rotary table device.

Rotary Positioning Tables use a precision machined worm gear assembly and either ball, cross roller, or angular contact bearings to support the table top load. Different gear ratios allow for either high resolution or high speed in a low profile package. The use of any step motor, or servo motor system to drive this rotary table is a key advantage. This allows the use of a preferred motion control system.

Items to Review

When selecting a positioning table, each of the following items should be reviewed thoroughly by the user. Some items will not be of major importance for a specific application. However, by reviewing each and every item, a positioning table can be selected that will give the required performance over the life of the system.

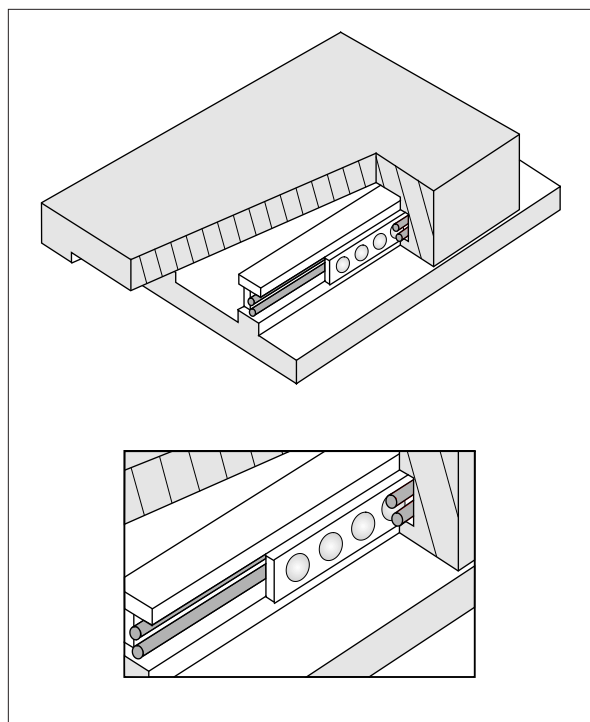
- Bearing Designs** - Linear (ball, cross roller, round rail, square rail, and air) bearings, along with rotary bearings. (See pages A-10 to A-12)
- Drive Mechanisms** (acme screws, ball screws, belt, and worm gears). See pages (A-13 to A-15)
- How to Select a Positioning Table** which includes safety factors and travel life. (See page A-16)
- Load Capacities** of all the critical elements of a positioning table need to be thoroughly reviewed in order to select the proper table for a given application. This includes capacities for bearings, drive mechanisms, and table structures. (See pages A-17 to A-27)
- Maximum Speed** of a positioning table sometimes depends on the bearing components and sometimes depends on the drive mechanism. (See page A-28)
- Acceleration & Thrust Forces** are parameters that can put extra stresses on positioning table components in certain situations. (See page A-29)
- Accuracy & Repeatability** are two of the most misunderstood parameters when selecting a positioning table. By determining what it is you really need, will help you select a cost effective positioning system. (See pages A-30 to A-33)
- Table Physical Size** (See page A-34)
- Lubrication** (See page A-35)
- Mounting Considerations** (See page A-36)
- Motor Couplings** (See page A-37)
- EOT (end of travel) & Home Switches** (See page A-38)
- Encoders** (See page A-39)
- Power-off Brakes** (See page A-40)
- Multi-Axis Systems** (See page A-41)
- Environments** (See page A-42)
- Testing** (See page A-43)
- Custom Systems** (See page A-44)
- Application Guide** (See page A-45)
- Motor Sizing** (See pages A-46 to A-49)

Bearing Designs

The main function of a positioning table's linear, or rotary bearing is to carry the user mounted load while the table is in motion. The bearings are also a key element in determining the overall positioning table accuracy and repeatability. Each bearing design provides advantages and disadvantages in load capacity, size, cost, stiffness, and friction. Selecting a positioning table with the right bearing design for a given application is essential.

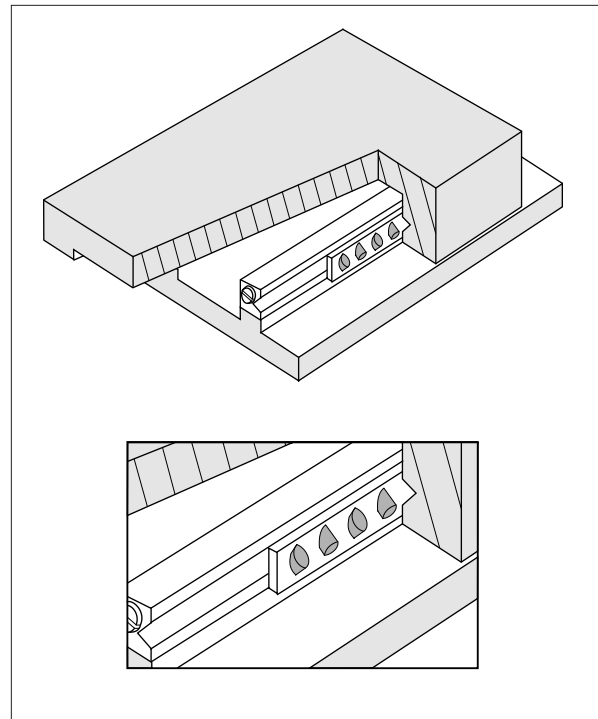
Linear bearings are also a key element in determining how straight and flat a linear positioning table is, which helps determine accuracy & repeatability. The five primary linear bearings used within positioning tables are ball & rod, cross roller, round rail, square rail, and air bearing.

Ball & rod bearing tables use two rows of non-recirculating steel balls that are rolling between four steel rods located on each side of the table. Two of the steel rods are mounted the entire length of the table base, while the other two steel rods are mounted the entire length of the table carriage on each side of the table. The ball bearings, which are held in a retainer assembly, roll between the steel rods on the base and the steel rods on the carriage, as the carriage moves. This design produces point contact for loading between the steel rods and rolling balls. This provides a low friction, smooth operating system at an economical price. However, this design is limited to light loads, short travel lengths, minimal moment loads, and is difficult to preload. Because the carriage extends past the base as it travels, this table requires a larger horizontal envelope area and protective shields like cover plates & waycovers can not be used.



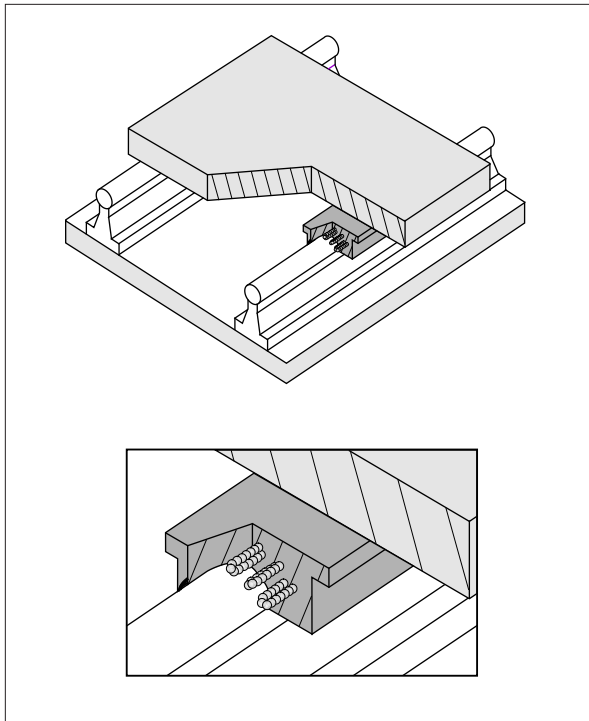
Ball & Rod Bearing

Cross roller linear bearing tables are very similar in operation as the ball & rod bearing tables. The rolling balls are replaced with cylindrical rollers, and the steel rods are replaced with ground "V" ways. The larger surface contact between the rollers & "V" ways typically increases the table load capacity by up to 3 times more over a comparable ball & rod type system. These table designs also produce better flatness and straightness specifications over the ball & rod type. Thus they are typically used in higher accuracy type of applications. However, they have the same disadvantages as the ball & rod type tables which are short travel lengths, minimal moment load capacity, large horizontal envelope area, and no possibility of using protective cover plates or waycovers.



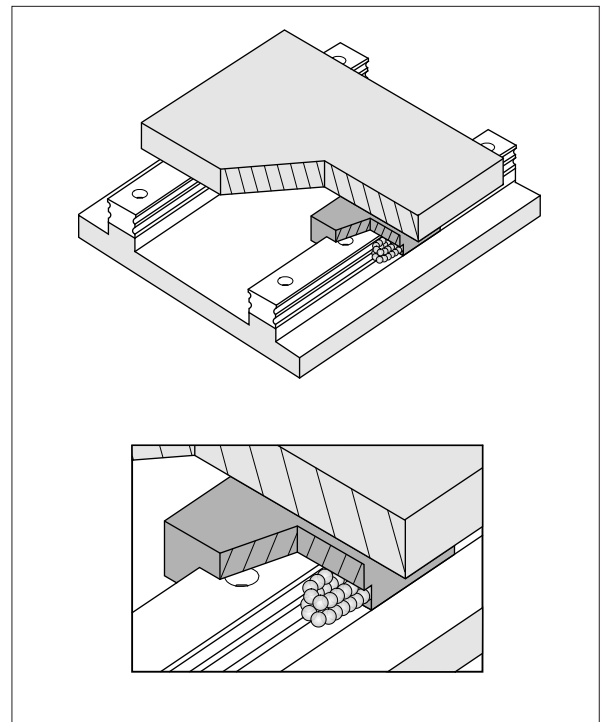
Cross Roller Bearing

Round rail linear bearings use four bushings with recirculating balls which are mounted within either two, or four pillow blocks. The pillow blocks are then mounted to the carriage, which rides on two round, hardened & ground shafts (which are mounted to the base). Travel lengths are only limited by the available shaft and base length. The point contact between the recirculating balls in the bushing and the round shaft produces a very low friction positioning table. The greater number of balls contacting the ground shaft over a ball & rod type table, provides for a larger load capacity system. This table design provides long travel lengths, good load capacities, large moment load capacities, and can accommodate protective cover plates & waycovers.



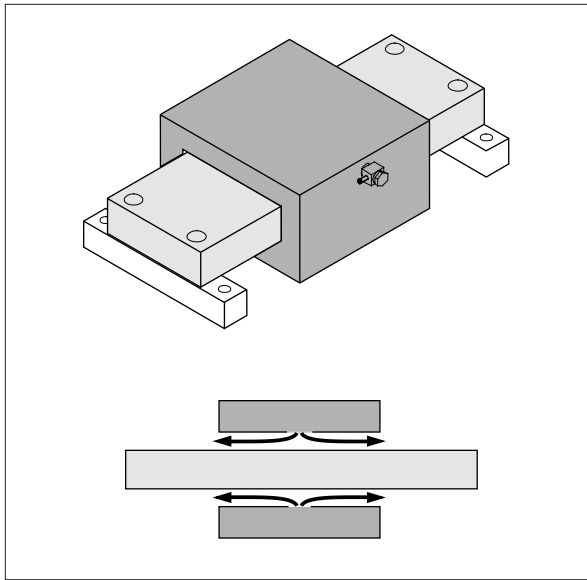
Round Rail Bearing

Square rail (linear guide) bearing tables are very similar in operation as the round rail tables. The round shaft has been replaced with a rectangular (square) rail, while the round rail bushing has been replaced with a rectangular bearing block. The recirculating balls in the bearing block contact more surface area on the curved ball race on the square rail. This design provides a table that has increased load capacity, increased moment load capacity, and higher system rigidity over the round rail. Because of the precision ground ball races on the rails, these linear bearings will have better flatness & straightness specifications than a round rail system. Table travels are only limited by the available rail, and base length. This table design is also able to handle shock & vibration forces better than a round rail system due to its bearing design, and can accommodate protective cover plates & waycovers.



Square Rail Bearing

Air bearing linear tables create a small air cushion between the table carriage and the table base (guide rail). This provides a non-contact linear bearing system that is rigid, friction free, and cog-free. Using a very accurate guide rail (rectangular or square) can produce excellent flatness & straightness specifications. Typical drive mechanisms include high accuracy acme screws and linear motors. Using a high accuracy non-contact linear motor drive system, and a high accuracy non-contact linear encoder, can produce a very accurate positioning table, one that could virtually last forever.



Air Bearing

Rotary bearings are a key element in determining how much vertical, radial, and axis runout a rotary positioning table has, along with its load capacity. The typical designs used in rotary tables are ball, cross roller, angular contact, and four point contact radial bearings.

Ball bearing rotary tables typically use one or two radial bearings to support the load as the table top rotates. This design provides for a relatively low profile table with a small load capacity, while minimizing runout errors.

Cross roller bearing rotary tables are very similar in operation as the ball bearing rotary tables. The rolling balls have been replaced with cylindrical rollers. This design provides for a relatively low profile table with a larger load capacity than the ball bearing tables. Runout errors are typically the same to less than the ball bearing table.

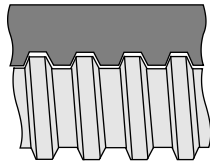
Angular contact bearing rotary tables use one or two angular contact bearings to support the load as the table top rotates. This design provides for a larger load capacity table than the ball bearing table, which can also handle small moment loads. Typically these tables have a higher profile than a ball bearing table, yet have the same range of runout errors.

Four point contact bearing rotary tables use 2 four point contact bearings to support the load as the table top rotates. This design provides for a large load capacity table that can handle higher moment loads than other designs. This bearing design also allows for large through holes.

Drive Mechanisms

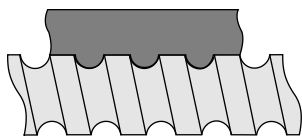
The main function of the drive mechanism within a positioning table is to move the load. It is an element that contributes to position accuracy, repeatability, speed, and mechanical system resolution. The linear drive mechanisms *LINTECH* uses include acme screws, ball screws, and belt & pulley assemblies. Precision worm gear assemblies are the main rotary drive mechanism used.

Acme screws typically use a turcite (polymer), or bronze nut. The nut, which is attached to the table carriage, moves back and forth along the linear bearing system as the screw rotates. The nut threads ride in the matching acme screw threads, much like the ordinary nut and bolt system. This produces a higher friction (lower efficiency) system than a ball screw assembly, since there are no rolling elements between the nut and the acme screw threads. Acme screws work fine for applications requiring low speeds, noise and duty cycles. Also, an acme screw is a good choice for most vertical applications, as it typically prevents back-driving of the attached load. However, the friction of the acme screw can affect low speed smoothness (in some applications) and its long term life is significantly lower than a ball screw.



Acme Screw

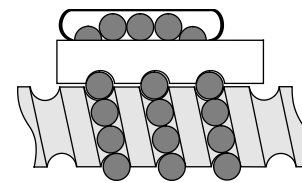
The **Turcite nut** option available with rolled ball screws operates very similar to an acme screw. The polymer nut contacts the ball screw grooves differently than an acme screw assembly does. This produces a drive mechanism that has less friction than an acme screw, thus potentially allowing for higher speeds and less input torque required from an attached motor for a given application. It provides smooth motion, low audible noise, and is ideal for vertical applications. Also, using the turcite nut with high lead ball screws provides for faster linear speeds.



Turcite Nut with Ball Screw

Ball screws are the 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 grooves, providing an efficient low friction system. The nut, which is attached to the table carriage, moves back and forth with the linear bearing system as the screw rotates. Using a higher lead ball screw (for example 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.

LINTECH provides three different ball screw configurations. The rolled ball screw system utilizes a tapped nut with a standard accuracy grade rolled screw. The precision ball screw system utilizes a ground nut with a higher accuracy grade rolled screw. The ground ball screw system utilizes a ground nut with a high accuracy precision ground screw. See the chart on page A-14 for a more general comparison of the different screws *LINTECH* provides in its positioning tables.



Ball Screw

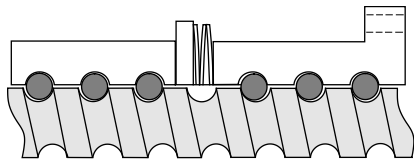
Accuracy grades of acme screws and ball screws is typically reflected by its "lead error" specification, which is generally given in a "in/ft" (microns/300 mm) rating. This "lead error" is the primary element in determining the position accuracy of a positioning table. The better the "lead error" (better position accuracy), the more costly the screw assembly. *LINTECH* provides position accuracy specifications for the different screw assemblies in each table series section. Higher grade accuracy acme, and ball screws are available upon request.

Drive Mechanisms

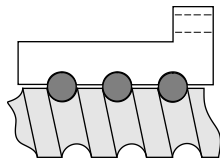
Screw Drive Comparison Chart

Consideration	Acme Screw	Ball Screws			Comments
		Rolled	Precision	Ground	
Audible noise	least audible noise	most audible noise	less audible noise than rolled screw	less audible noise than precision screw	Acme: 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	Acme: good for light loads & 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 <i>non-preloaded nut</i>	will increase with wear	constant	constant	constant	Acme: preloaded nut assembly eliminates backlash. Ball: preloaded nut assembly eliminates backlash.
Duty Cycle	low to medium (< 50 %)	high (100 %)	high (100 %)	high (100 %)	Acme: 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	long	long	long	Acme: mechanical wear related to duty cycle, load & speed. Ball: minimal wear if operated in proper environment, within load specifications, and periodically lubricated.
Relative - Cost	slightly more than rolled ball	least expensive	slightly more than rolled ball	most expensive	Acme: a little more expensive than the rolled ball screw. Ball: due to more accurate manufacturing procedures precision rolled & ground ball screws are more expensive.
Screw Efficiency	low 40 % -Acme 60 % -Turcite	high (90 %)	high (90 %)	high (90 %)	Acme: low efficiency due to high sliding friction. Ball: high efficiency due to recirculating balls in nut assembly - low friction system.
Smoothness	can be smooth	least smooth	medium smoothness	smoothest	Acme: due to friction can start/stop 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	Acme: 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.

Preloading of an acme, or ball screw nut is the process of eliminating backlash within the nut assembly. Eliminating the backlash in a nut becomes important for those applications requiring good bidirectional positioning and repeatability. Also, eliminating nut backlash can help stabilize an electronic motion controller. Some assemblies use two nuts that are separated by a spring (or spacer) which provides a force between the two nuts. This process is used with acme screw, rolled ball screw, and precision ball screw assemblies. The ground ball screw option typically eliminates backlash by using "oversized" recirculating balls in one nut that is matched to the screw thread. *LINTECH* sets all standard preloaded nut assemblies in this catalog to a light preload. This light preload force removes backlash while creating minimal breakaway torque. For a given application, if a set preload force (or a specific breakaway torque value is required), contact *LINTECH* before ordering. Also, be aware that increasing the nut assembly preload will decrease its life.



Two Nut Preloaded Ball Screw Assembly

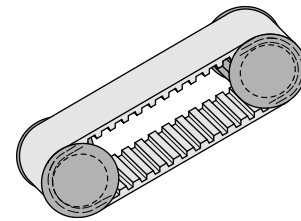


One Nut Preloaded Ball Screw Assembly

Resolution of a screw driven positioning table is directly related to the lead of the screw. This resolution is a mechanical table resolution, not a system resolution. The system resolution needs to take into consideration the motor/drive control resolution. The lead of a screw is the distance traveled by the nut (or carriage) for one revolution of the screw. Therefore, a screw with a 0.200 inch lead will travel 1.000 inch when the screw rotates five (5) revolutions. While a screw with a 0.500 inch lead will travel 1.000 inch in just two (2) screw revolutions. Using the screw with a 0.200 inch lead will provide better mechanical resolution over the screw with the 0.500 inch lead. However, the 0.500 inch lead screw will require more motor torque to move a given load. *LINTECH* provides a wide selection of screw leads for each table series (see individual table sections)

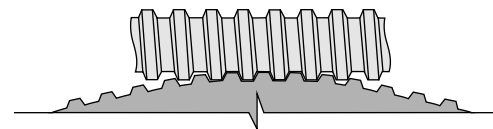
Maximum speed of a screw driven positioning table depends on the screw diameter, screw lead, screw length, and the screw end bearing supports. *LINTECH* uses fixed-simple screw end supports in its positioning tables. Using a screw with a higher lead (i.e. a 0.500 inch lead instead of a 0.200 inch lead) will provide higher linear speeds. Individual table sections provide charts indicating the maximum speed for a given travel length using a specific screw.

Belt & pulley driven linear positioning tables use a high strength, steel reinforced polyurethane belt and two pulleys. Belt driven tables provide a solution for those high speed (and/or long travel) applications which require good repeatability. Belt drive system resolution (lead) is determined by the pitch diameter of the drive pulley. The maximum speed for a given application is either limited by the linear bearing top speed or the thrust force capacity of the belt.



Belt & Pulley Assembly

Rotary positioning tables use a precision worm gear assembly as the drive mechanism. The assembly consists of a worm wheel and a worm shaft. These gears are precision machined in matched sets, and are lapped to provide very smooth motion. This provides very precise positioning with little backlash. However, the high friction of the worm gear assembly limits the tables top speed, efficiency, and duty cycle. Gear ratios from 30:1 to 360:1 are available with these positioning tables.



Worm Gear Assembly

Specifications

Reviewing the required application load, life, speed, repeatability, position accuracy, and environmental conditions against a manufacturer's specifications for a given table, should be an easy process. However, here lies the problem. There is no industry standard for specifying the ratings of positioning tables. As an example, the load rating for a specific positioning table is given as a dynamic, static, or structural capacity. Rating a table by each of these parameters can yield a different load capacity (or life) for that table, even though all the tables may have the exact same components within it.

LINTECH has taken the following approach for the rating of its positioning tables. We provide the maximum capacities for all the critical components of a table. Then by the use of some equations and safety factors, one can estimate the life of a positioning table for a given application. This process not only allows for the selection of a cost effective table solution for a simple application, but also will help with the correct selection of a positioning table for those very demanding applications.

Safety Factors

As a practice, safety factors should always be used when selecting a positioning table for a given application. For most real world applications, generally people do use safety factors. However, sometimes the incorrect safety factor, or no safety has been used. This can lead into an unexpected system failure. *LINTECH* provides, in a chart form, different safety factor recommendations for each of the critical elements within a positioning table. Keep in mind that these recommendations for safety factors are not hard & fast rules. Safety factors for a specific table element may have to be increased (or decreased) due to the application requirements.

Load Ratings

The applied load that a positioning table will see needs to be compared against the load capacities of all critical components within a given table. *LINTECH* publishes several load capacities for each positioning table series. Some of these capacities are dynamic, and some are static. These capacities mainly deal with the linear bearing system, the drive mechanism, and the structure of the table. Static values are capacities of the components with the table at rest (not in motion). Dynamic capacities pertain to the table in motion and are typically based on the number of inches (or km) traveled.

Required Life

It is important to evaluate the required (or expected) life from a positioning table for a given application load. Below are two examples which illustrate the importance of a dynamic load rating based upon travel life. As shown, these two applications could lead to the selection of two very different positioning tables, even though the applied user load is the same 150 lbs (68 kg).

Example 1:

assembly needs to last 6 years
with
a 10 inch move out, then back 10 inches every 90 seconds
for
8 hours per day
for
5 days per week
and
50 weeks per year

$$\frac{(10 \times 2) \text{ inches}}{90 \text{ sec}} \times \frac{60 \text{ sec}}{1 \text{ min}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{8 \text{ hr}}{1 \text{ day}} \times \frac{5 \text{ days}}{1 \text{ week}} \times \frac{50 \text{ weeks}}{1 \text{ yr}} \times 6 \text{ years} = \mathbf{9,590,400} \text{ inches of travel}$$

Example 2:

assembly needs to last 8 years
with
(24) 1 inch moves out, then back 24 inches every 30 seconds
for
12 hours per day
for
7 days per week
and
52 weeks per year

$$\frac{(24 \times 2) \text{ inches}}{30 \text{ sec}} \times \frac{60 \text{ sec}}{1 \text{ min}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{12 \text{ hr}}{1 \text{ day}} \times \frac{7 \text{ days}}{1 \text{ week}} \times \frac{52 \text{ weeks}}{1 \text{ yr}} \times 8 \text{ years} = \mathbf{201,277,440} \text{ inches of travel}$$

Linear Bearing Load Capacities

Linear Bearing Load Capacities of a positioning table are specified with a static and dynamic value. These values are used to help select the proper table for a given load/life application. The use of adequate safety factors is a key element in the selection process of a linear bearing system for a given application. Selecting a system with no safety margin can lead to problems relating to performance and long term life.

Static Loads can exert an extreme force upon the linear bearing system in a non-moving state. If a static load rating of a particular linear bearing is exceeded, a localized permanent depression in the bearing and rail races could cause the system to not operate smoothly or fail prematurely.

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. To ensure proper life, external forces should never come close to the static load rating. Repeated forces at or near the maximum rating can fatigue the elements causing premature failure. Thus, a safety factor should be considered to account for these forces. Also by using a safety factor, extra unforeseen loads that arise within an application sometime in the future, would not affect the positioning table chosen.

Recommended Linear Bearing Static Safety Factors

Operation Conditions	Loading Type	Min. Safety Factor
Stationary	No applied impact or vibration loads.	2.0 - 3.0
	Small impact or vibration loads are present.	3.0 - 4.0
	High impact or vibration loads are present.	4.0 - 6.0

Chart 1

Example 3:

Application calls for an external 1,500 lbs of force to be applied to a part (weight = 100 lbs) that is mounted to a positioning table. The table will be at rest. There will be a small impact to the part (and positioning table) as the force is first being applied.

From chart 1 - use a 3.5 factor

<i>total load</i>		<i>factor</i>		<i>select a table that has a static capacity greater than this value</i>
(1,500 + 100)	X	3.5	=	5,600 lbs

Dynamic Loads exert a force upon the linear bearings while the table is in motion. Every linear bearing (or carriage assembly) has a load capacity associated with it that is based upon the number of inches (or km) traveled. If the load applied to the carriage is less than the rated value at 2 million inches (50 km) of travel, the linear bearings will have a longer life associated with them that is exponential. Therefore, in order to select a positioning table that will last the required travel life in an application, the forces acting upon the linear bearings need to be reviewed. Once the force on the heaviest loaded bearing has been determined, and a proper safety factor selected, the life of that bearing (and carriage) can be determined by using a simple mathematical equation.

Safety factors should always be used when calculating the life of a linear bearing. Even though the forces acting upon a bearing (or carriage assembly) can be calculated, other parameters cannot. Changing loads, speeds, acceleration rates, environments and lack of lubrication produce extra forces (stresses) acting upon the linear bearings that are hard to quantify. As a positioning table moves, there are additional resultant loads as a by-product. The rate at which the table begins to move a load, can have a large impact on the life of a linear bearing. The linear bearings see 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 and cause premature failure.

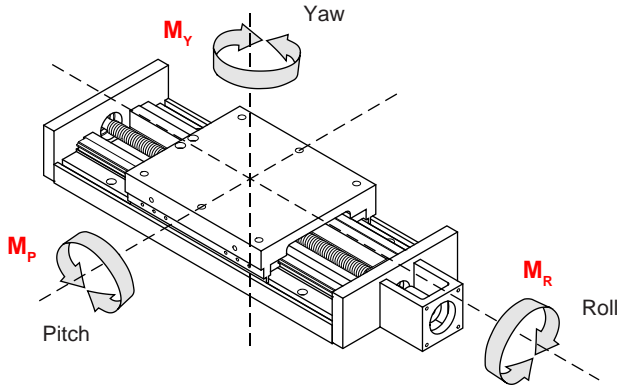
Recommended Linear Bearing Dynamic Safety Factors

Impacts or Vibration	Speed (in/sec)	Acceleration (G's)	Min. Safety Factor
None	< 5	< 0.25	1.0 - 2.0
Small	5 - 10	0.25 - 0.50	2.0 - 3.0
Medium	10 - 20	0.50 - 1.00	3.0 - 4.0
Large	20 - 50	1.00 - 1.50	4.0 - 6.0
Very Large	> 50	> 1.50	6.0 - 8.0

Chart 2

Linear Bearing Load Capacities - Continued

When the user load is applied to the carriage center, the forces acting upon each individual bearing are generally shared. However, if the load center of gravity is located away from the carriage center, a moment load has been created. These moment loads produce different forces acting upon the individual bearings within a table. Calculating precisely the exact forces acting upon an individual bearing in a moment load situation can be very involved. The equations on pages A-20 to A-22 can be used to estimate the forces acting upon an individual bearing, in a multiple rail and bearing table configuration. The chart on page A-19 was created by *LINTECH* as a means to quickly view the different load capacities for the positioning tables featured in this catalog. The ratings for Roll (M_R), Pitch (M_P), and Yaw (M_Y) for each table series are based upon the load center of gravity being located 12 inches (305 mm) from the carriage center. These ratings can be used as a general guideline for selecting a particular table for a given application.



Once the applied force acting upon an individual bearing (or carriage) has been determined, the following equations can be used to either determine the life, or the required load capacity, of a table series.

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

$$R = \left[\frac{L}{B} \right]^{1/3} \times F \times S$$

- L** = calculated travel life (millions of inches or Km)
- R** = rated dynamic load capacity of carriage (or each bearing) at 2 million inches of travel or 50 Km
- F** = user applied load
- S** = safety factor (1 to 8) see chart 2 on page A-17
- B** = either 2 (for millions of inches) or 50 (for Km)

Example 4:

Application calls for a screw driven horizontal application with a 30 lb load. The center of gravity of the load is located 18 inches perpendicular from the carriage center. Maximum speed is 4 inches/sec with an acceleration rate of 0.30 g's. There are no external impact loads. Would like a travel life of 150 million inches. Which table series should be considered?

- 1) From chart 2 on page A-17 - use a 2.5 safety factor
- 2) Find the M_R force for 30 lbs at 18 inches:

$$\frac{30 \times 18}{12} = 45 \text{ ft-lbs}$$

- 3) Use the following equation to find R:

$$R = \left[\frac{L}{B} \right]^{1/3} \times F \times S$$

$$R = \left[\frac{150}{2} \right]^{1/3} \times 45 \times 2.5$$

$$R = 474 \text{ ft-lbs}$$

- 4) From the chart on Page A-19 these tables should be considered:

Table Series	Dynamic M_R Capacity
150 4 bearing	575 ft-lbs
160 4 bearing	740 ft-lbs

Example 5:

Application calls for a screw driven horizontal application with a 75 lbs load mounted to the carriage center. Maximum speed is 8 inches/sec with an acceleration rate of 0.8 g's. There are no external impact loads. What would the estimated travel life be using a 2 bearing 100 table series?

- 1) From chart 2 on page A-17 - use a 4.0 safety factor
- 2) From the chart on page A-19 - Dynamic horizontal load capacity of 2 bearing 100 series at 2 million inches is 1,550 lbs.
- 3) Use the following equation to find L:

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

$$L = \left[\frac{1,550}{75 \times 4} \right]^3 \times 2$$

$$L = 276 \text{ million inches of travel}$$

Linear Bearing Load Capacities - Continued

Table Series	Carriage Length inches (mm)	# of Bearings	Static Capacity			Dynamic Capacity 2 million inches (50 km) of travel		
			Horizontal	M _R	M _P & M _V	Horizontal	M _R	M _P & M _V
			lbs (kg)	ft-lbs (N-m)	ft-lbs (N-m)	lbs (kg)	ft-lbs (N-m)	ft-lbs (N-m)
130	4 (102)	1	200 (90)	14 (19)	8 (10)	100 (45)	8 (11)	4 (5)
		2	400 (180)	28 (38)	30 (40)	200 (90)	16 (22)	15 (20)
100 110 120	4 (102)	2	2,360 (1070)	210 (285)	30 (41)	1,550 (703)	140 (190)	18 (24)
		4	4,720 (2140)	425 (576)	365 (495)	3,100 (1406)	280 (379)	240 (325)
90	6 (152)	4	5,000 (2268)	575 (780)	225 (305)	3,300 (1496)	380 (515)	150 (203)
	12 (305)	4	5,000 (2268)	575 (780)	790 (1071)	3,300 (1496)	380 (515)	525 (712)
150	4 (102)	2	3,400 (1542)	515 (698)	100 (136)	1,900 (862)	285 (386)	56 (76)
	8 (203)	4	6,800 (3084)	1,030 (1396)	1,255 (1702)	3,800 (1724)	575 (780)	700 (949)
160 170 180	6 (152)	2	4,200 (1905)	660 (895)	91 (123)	2,800 (1270)	370 (502)	51 (69)
		4	8,400 (3810)	1,320 (1790)	1,205 (1634)	5,600 (2540)	740 (1003)	670 (908)
200	6 (152)	2	7,600 (3447)	1,365 (1851)	300 (407)	4,400 (1996)	790 (1071)	175 (237)
	12 (305)	4	15,200 (6895)	2,730 (3701)	4,300 (5830)	8,800 (3992)	1,580 (2142)	2,485 (3369)
550	555	2	16,360 (7420)	285 (386)	845 (1145)	9,120 (4136)	172 (233)	510 (690)
	553 554	2	12,580 (5706)	590 (800)	1,750 (2370)	10,320 (4681)	475 (644)	1,425 (1932)
250	6 (152)	2	13,600 (6169)	2,715 (3681)	635 (861)	8,300 (3765)	1,655 (2244)	455 (617)
	12 (305)	4	27,200 (12338)	5,425 (7355)	6,450 (8745)	16,600 (7530)	3,310 (4488)	3,930 (5328)

Mean Bearing Load Calculation

When the force acting upon an individual bearing varies widely, as is the case with the bottom axis bearings of a multi-axes positioning table, a mean bearing load calculation can help determine the life of that bearing.

$$F_{avg} = \frac{1}{3} (F_{min} + 2 \times F_{max})$$

F_{avg} - average force acting upon bearing (lbs or kg)

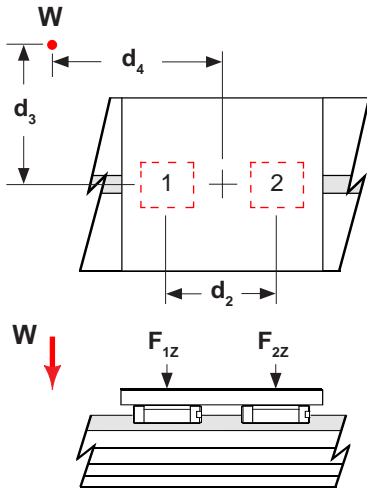
F_{min} - minimum force acting upon bearing (lbs or kg)

F_{max} - maximum force acting upon bearing (lbs or kg)

The equations below can be used to estimate the forces acting upon the linear bearings in a positioning table. These equations pertain to a positioning table which is at constant uniform velocity, or with the positioning table at rest. During acceleration and deceleration intervals of a positioning table, the force exerted upon an individual bearing changes as the acceleration or deceleration rate varies. In most cases, the extra force acting upon an individual bearing during the acceleration interval is offset by a reduced force during the deceleration interval. Therefore, using just the constant uniform velocity equations will adequately determine the life of an individual bearing for a particular application.

- d_1 - distance between centerlines of shafts or rails (in or mm)
- d_2 - distance between centerlines of bearing blocks (in or mm)
- d_3 - distance between carriage center and load center of gravity (in or mm)
- d_4 - distance between carriage center and load center of gravity (in or mm)
- d_r - distance between carriage surface and linear bearings (in or mm)
- C** - conversion from (inches to feet) (1/12) or (mm to meters) (1/1000)
- W** - load weight (lbs or kg)
- F_{BT}** - total force acting upon bearing (lbs or kg)
- F_{BX}** - force acting upon bearing in X-axis direction (lbs or kg)
- F_{BY}** - force acting upon bearing in Y-axis direction (lbs or kg)
- F_{BZ}** - force acting upon bearing in Z-axis direction (lbs or kg)
- F_(r)** - rated capacity of bearing at 2 million inches (50 km) (lbs or kg)
- M_{R(r)}** - rated roll moment capacity of carriage at 2 million inches (50 km) (ft-lbs or N-m)

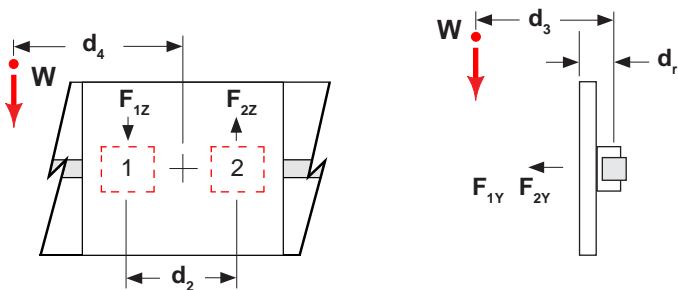
Horizontal Applications One (1) rail & two (2) bearings



$$F_{1z} = \frac{W}{2} + \left[W \times \frac{d_4}{d_2} \right] + F_{(r)} \times \left[\frac{W \times d_3 \times C}{M_{R(r)}} \right]$$

$$F_{2z} = \frac{W}{2} - \left[W \times \frac{d_4}{d_2} \right] + F_{(r)} \times \left[\frac{W \times d_3 \times C}{M_{R(r)}} \right]$$

Side Mounted Applications One (1) rail & two (2) bearings

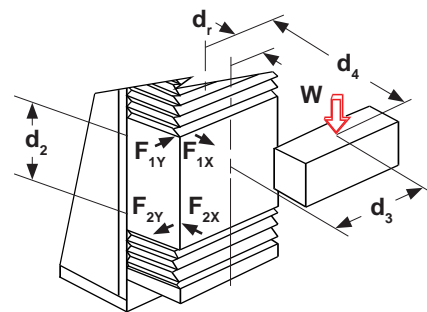


$$F_{1z} = \frac{W}{2} + \left[W \times \frac{d_4}{d_2} \right] \quad F_{1y} = F_{(r)} \times \left[\frac{W \times d_3 \times C}{M_{R(r)}} \right]$$

$$F_{2z} = \frac{W}{2} - \left[W \times \frac{d_4}{d_2} \right] \quad F_{1y} = F_{2y}$$

$$F_{1T} = F_{1z} + F_{1y}$$

Vertical Applications One (1) rail & two (2) bearings



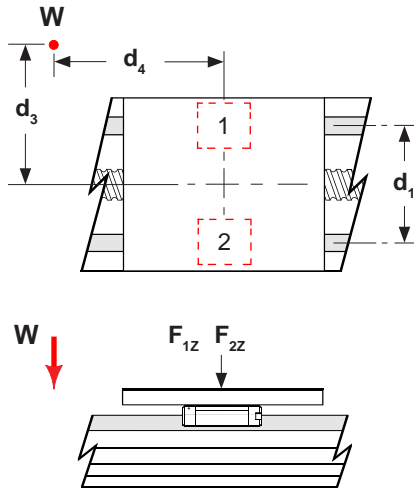
$$F_{1x} = F_{2x} = W \times \frac{d_4}{d_2} \quad F_{1y} = F_{2y} = W \times \frac{d_3}{d_2}$$

$$F_{1T} = F_{1x} + F_{1y}$$

The equations below can be used to estimate the forces acting upon the linear bearings in a positioning table. These equations pertain to a positioning table which is at constant uniform velocity, or with the positioning table at rest. During acceleration and deceleration intervals of a positioning table, the force exerted upon an individual bearing changes as the acceleration or deceleration rate varies. In most cases, the extra force acting upon an individual bearing during the acceleration interval is offset by a reduced force during the deceleration interval. Therefore, using just the constant uniform velocity equations will adequately determine the life of an individual bearing for a particular application.

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- F_{BY} - force acting upon bearing in Y-axis direction (lbs or kg)
- F_{BZ} - force acting upon bearing in Z-axis direction (lbs or kg)
- $F_{P(t)}$ - rated capacity of bearing at 2 million inches (50 km) (lbs or kg)
- $M_{P(t)}$ - $M_{Y(t)}$ - rated pitch (or yaw) moment capacity of carriage at 2 million inches (50 km) (ft-lbs or N-m)

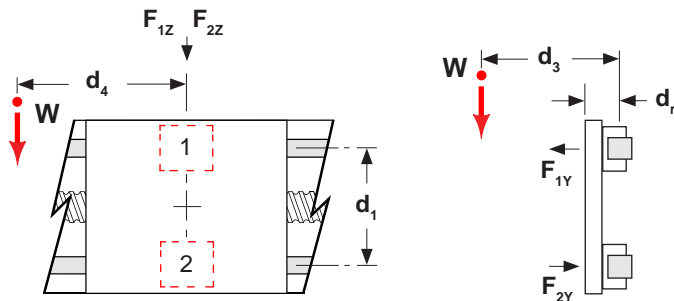
Horizontal Applications Two (2) rails & two (2) bearings



$$F_{1z} = \frac{W}{2} + \left[W \times \frac{d_3}{d_1} \right] + F_{(t)} \times \left[\frac{W \times d_4 \times C}{M_{P(t)}} \right]$$

$$F_{2z} = \frac{W}{2} - \left[W \times \frac{d_3}{d_1} \right] + F_{(t)} \times \left[\frac{W \times d_4 \times C}{M_{P(t)}} \right]$$

Side Mounted Applications Two (2) rails & two (2) bearings



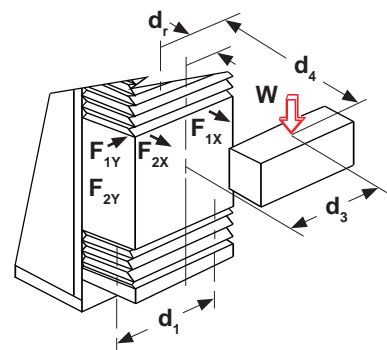
$$F_{1z} = F_{(t)} \times \left[\frac{W \times d_4 \times C}{M_{Y(t)}} \right]$$

$$F_{1y} = F_{2y} = W \times \frac{d_3}{d_1}$$

$$F_{1z} = F_{2z}$$

$$F_{1T} = F_{1z} + F_{1y}$$

Vertical Applications Two (2) rails & two (2) bearings



$$F_{1x} = F_{2x} = F_{(t)} \times \left[\frac{W \times d_4 \times C}{M_{P(t)}} \right]$$

$$F_{1T} = F_{1x} + F_{1y}$$

$$F_{1y} = F_{2y} = F_{(t)} \times \left[\frac{W \times d_3 \times C}{M_{Y(t)}} \right]$$

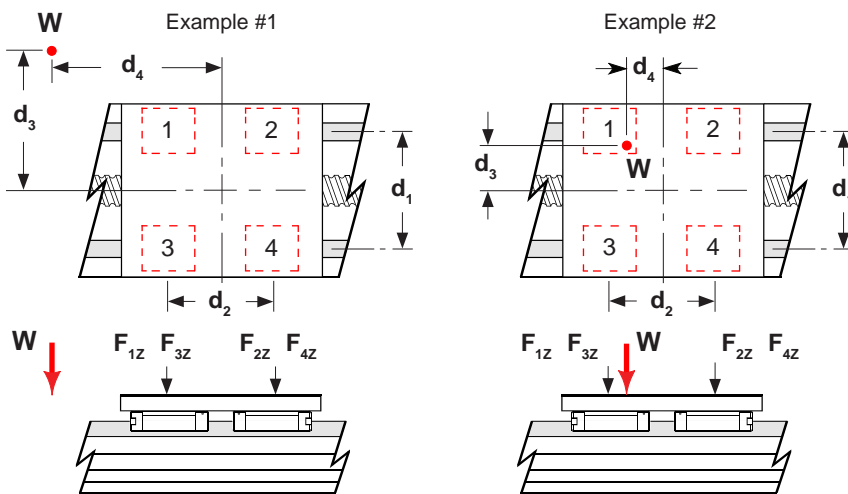
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- d_4 - distance between carriage center and load center of gravity (in or mm)
- d_r - distance between carriage surface and linear bearings (in or mm)

- F_{BT} - total force acting upon bearing (lbs or kg)
- F_{BX} - force acting upon bearing in X-axis direction (lbs or kg)
- F_{BY} - force acting upon bearing in Y-axis direction (lbs or kg)
- F_{BZ} - force acting upon bearing in Z-axis direction (lbs or kg)
- M_{RB} - roll moment load acting upon a bearing (in-lbs or N-mm)
- M_{YB} - yaw moment load acting upon a bearing (in-lbs or N-mm)
- M_{PB} - pitch moment load acting upon a bearing (in-lbs or N-mm)
- W - load weight (lbs or kg)

Horizontal Applications

Two (2) rails & four (4) bearings



$$F_{1z} = \frac{W}{4} + \left[\frac{W}{2} \times \frac{d_4}{d_2} \right] + \left[\frac{W}{2} \times \frac{d_3}{d_1} \right]$$

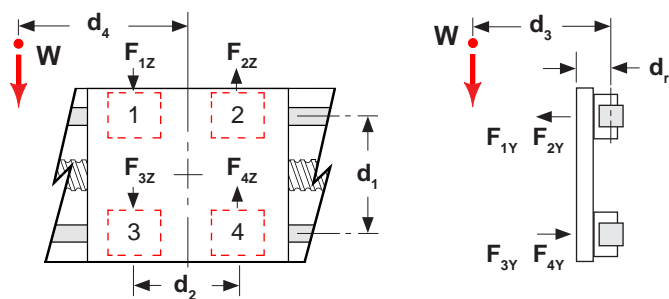
$$F_{2z} = \frac{W}{4} - \left[\frac{W}{2} \times \frac{d_4}{d_2} \right] + \left[\frac{W}{2} \times \frac{d_3}{d_1} \right]$$

$$F_{3z} = \frac{W}{4} + \left[\frac{W}{2} \times \frac{d_4}{d_2} \right] - \left[\frac{W}{2} \times \frac{d_3}{d_1} \right]$$

$$F_{4z} = \frac{W}{4} - \left[\frac{W}{2} \times \frac{d_4}{d_2} \right] - \left[\frac{W}{2} \times \frac{d_3}{d_1} \right]$$

Side Mounted Applications

Two (2) rails & four (4) bearings

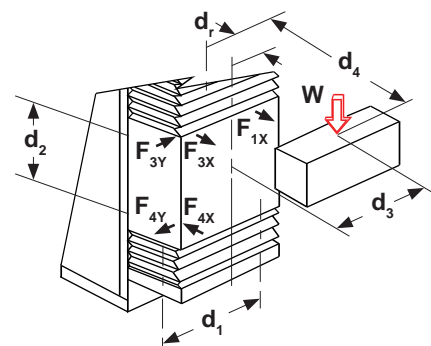


$$F_{1z} = F_{3z} = \frac{W}{4} + \left[\frac{W}{2} \times \frac{d_4}{d_2} \right] \quad F_{1y} \sim F_{3y} = \left[\frac{W}{2} \times \frac{d_3}{d_1} \right]$$

$$F_{2z} = F_{4z} = \frac{W}{4} - \left[\frac{W}{2} \times \frac{d_4}{d_2} \right] \quad F_{1T} = F_{1z} + F_{1Y}$$

Vertical Applications

Two (2) rails & four (4) bearings



$$F_{1X} \sim F_{3X} = \frac{W}{2} \times \frac{d_4}{d_2}$$

$$F_{1Y} \sim F_{3Y} = \frac{W}{2} \times \frac{d_3}{d_2}$$

$$F_{1T} = F_{1X} + F_{1Y}$$

Drive Mechanism Load Capacities

Linear positioning table drive mechanisms will have static and dynamic load capacity ratings for the acme screw, ball screw, and belt drive assembly. These values are used to help select a correct drive mechanism for a given load/life table application. For most **acme screw driven** positioning table applications, the screw (and not the linear bearing) is the major factor in determining the life of the table. This is due to the high friction of the nut assembly. For most **ball screw driven** positioning table applications, the linear bearing system (and not the screw) is the major factor in determining the life of the table. This is due to the high efficiency and high load capacity of the nut. For most **belt driven** positioning table applications, the linear bearing system (and not the belt) is the major factor in determining the life of the table. This is due in large part to the fact that belt driven tables usually travel lots of inches at high speeds. The use of adequate safety factors is a key element in the selection process of the drive mechanism for a given application. Selecting a system with no safety margin can lead to problems relating to performance and long term life.

The actual (axial) load a drive mechanism "sees" needs to be determined first. Then the effects of that load on the drive mechanism can be reviewed. For both **screw & belt driven** positioning tables, the actual load the drive mechanism experiences will vary as the table moves. During acceleration and deceleration intervals of a positioning table, the force exerted upon the drive mechanism changes as the acceleration or deceleration rate varies. In most cases, the extra force acting upon the drive mechanism during the acceleration interval is offset by a reduced force during the deceleration interval. Therefore, using just the forces acting upon the drive mechanism during constant velocity can be used. The applied (axial) load "as seen by the screw nut or belt" depends upon the table orientation. See the equations below.

Axial Load (as seen by the screw nut or belt)

<u>Horizontal Application</u>	<u>Vertical Application</u>
$F = (W \times \mu) + E$	$F = W + E$
E = externally applied extra forces	
F = applied axial load (as seen by the screw nut or belt)	
W = user mounted load weight	
μ = coefficient of friction for linear bearing system (0.01 for typical linear rail & bearing systems)	

Static Loads can exert an extreme force upon the drive assembly in a non-moving state. For **acme screw** driven tables, if the static load rating of a particular screw is exceeded, the nut assembly can permanently be deformed, or crack outright. For **ball screw** driven tables, if the static load rating of a particular screw is exceeded, a localized permanent depression in the screw shaft and ball nut could cause the system to not operate smoothly or fail prematurely. For **belt** driven tables, if the static load rating (maximum belt tensile force) of a particular belt is exceeded, the belt will permanently stretch, or tear. 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. 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. Thus, a safety factor should be considered to account for these forces. Also by using a safety factor, extra unforeseen loads that arise within an application sometime in the future, would not affect the positioning table chosen.

Recommended Screw Drive Assembly Static Safety Factors

Operation Conditions	Loading Type	Min. Safety Factor
Stationary	No applied impact or vibration loads.	1.5 - 2.0
	Small impact or vibration loads are present.	2.0 - 4.0
	High impact or vibration loads are present.	4.0 - 6.0

Chart 3

Example 6:

Application calls for a 100 lbs force to be applied to a part that is mounted to a screw driven Z axis (vertical) positioning table. The table will be at rest when the 100 lbs force is applied to the carriage. There will be no applied impact and there is no vibration. There is also 25 lbs worth of tooling hardware mounted to the table carriage.

From chart 3 - use a 2.0 factor

<i>total load</i>		<i>factor</i>		<i>select a screw that has a static capacity greater than this value</i>
(100 + 25)	X	2.0	=	250 lbs

Drive Mechanism Load Capacities - Continued

Dynamic loads exert an axial force upon the drive mechanism of a linear positioning table while the table is in motion.

The maximum axial force that a **belt driven** positioning table can handle is directly related to the maximum belt force capability of the belt & pulley assembly, which is determined by the belt material, belt width, and number of pulley teeth. Exceeding the maximum belt force capability will cause the belt to "skip" over pulley teeth (mis-position). Over time, continuous "skipping" of the belt over pulley teeth will weaken the belt, thus lowering the maximum belt force capability. The life of a belt & pulley drive mechanism will far exceed the life of a linear bearing system as long as the positioning table is operated below the maximum belt force capacity. See the individual table series sections for information on belt force capacities.

Every **ball screw driven** table has a load capacity associated with the nut that is based on the number of inches (or km) traveled. If the axial load applied to the nut is less than the rated value at 1 million inches (25 km) of travel, the nut will have a longer life associated with it that is exponential. With **acme screw driven** tables it is extremely difficult to accurately determine the life of the nut. Lubrication, speed, load, and environment all affect the wear of an acme screw. Increase of backlash & input torque, along with a decrease in system smoothness & position accuracy are all symptoms of acme screw wear. However, in some situations these symptoms may not immediately affect the application. **LINTECH** recommends the use of higher than normal safety factors within the screw life equations as a means to estimate the potential usable life of an acme screw.

The life of the screw nut may not be the limiting element for a given application. **LINTECH** offers a wide range of screw options for every table series. These screws provide different diameters, leads and load capacities. For some applications, the screw end support bearings may limit the life of a positioning table. See page A-25.

Safety factors should always be used when calculating the life of a screw assembly. Even though the forces acting upon a nut can be calculated, other parameters can not. Changing loads, speeds, acceleration rates, environments and lack of lubrication can produce extra forces acting upon the nut that are hard to quantify. As a positioning table moves, there are additional resultant loads as a by-product. The rate at which the table begins to move a load, can have a large impact on the life of a screw assembly. The screw will see 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 and cause premature failure.

Once the applied axial force acting upon a nut has been determined, the equations below can be used to either determine the life, or the required load capacity.

Recommended Screw Drive Assembly Dynamic Safety Factors

Impacts or Vibration	Speed (in/sec)	Acceleration (G's)	Min. Safety Factor
	< 5	< 0.25	1.0 - 2.0
Small	5 - 10	0.25 - 0.50	2.0 - 3.0
Medium	10 - 20	0.50 - 1.00	3.0 - 4.0
Large	> 20	> 1	4.0 - 8.0

Chart 4

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

$$R = \left[\frac{L}{B} \right]^{1/3} \times F \times S$$

- L** = calculated travel life (millions of inches or Km)
- R** = rated dynamic load capacity of nut at 1 million inches of travel or 25 Km (see screw specs in individual sections)
- F** = applied axial load (*as seen by the screw nut or belt*)
- S** = safety factor (1 to 8) see chart 4
- B** = either 1 (for millions of inches) or 25 (for Km)

Example 7:

Application calls for a screw driven, 6 inch travel vertical table with a 15 lbs load. Want to use an acme screw. Maximum speed is 4 inches/sec with an acceleration rate of 0.20 g's. Would like a travel life of 90 million inches. Find the required rated load capacity for the acme screw?

- 1) From chart 4 - use a 2.0 safety factor (**S= 2.0**)
- 2) From page A-23 for vertical loads:
F = 15 lbs
- 3) Use the following equation to find R:

$$R = \left[\frac{L}{B} \right]^{1/3} \times F \times S$$

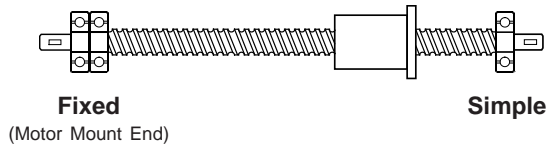
$$R = \left[\frac{90}{1} \right]^{1/3} \times 15 \times 2.0$$

$$R = 134 \text{ lbs}$$

- 4) Select an acme screw that has a dynamic load capacity greater than 134 lbs.

Screw Drive End Support Bearings

LINTECH uses sealed bearings in a fixed-simple configuration for end supports in screw driven positioning tables. The fixed-simple end support configuration eliminates end play of the screw shaft while supporting the ends of the screw. As LINTECH provides the use of a wide range of screws within each table series, the dynamic and static load capacity of the screw end support bearings also needs to be reviewed. In some cases, the limiting element of a screw assembly may be the end support bearing load capacity, and not the nut load capacity. See page A-24 for screw nut life/load information.



The axial (thrust) load that the screw end supports "see", can be derived by the same means as they were for the screw nut (see below). The use of safety factors here is also essential in determining the life of the end support bearings. The same hard to calculate dynamic & static forces that will act upon a nut will also act upon the end support bearings. Therefore, use the static safety factors in chart 3 (see page A-23) and the dynamic safety factors in chart 4 (see page A-24) when estimating the life of the end support bearings.

Axial (Thrust) Load (as seen by the screw end support bearings)

<u>Horizontal Application</u>	<u>Vertical Application</u>
$F = (W \times \mu) + E$	$F = W + E$
E = externally applied extra forces	
F = applied axial load (as seen by the bearings)	
W = user mounted load weight	
μ = coefficient of friction for linear bearing system (0.01 for typical linear rail & bearing systems)	

Once the applied axial force acting upon the screw end support bearings has been determined, the equations below can be used to either determine the life, or the required load capacity.

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

$$R = \left[\frac{L}{B} \right]^{1/3} \times F \times S$$

- L** = calculated travel life (millions or screw revs)
- R** = dynamic load capacity of bearings at 2 million screw revolutions (see specs in individual sections)
- F** = applied axial load (as seen by the bearings)
- S** = safety factor (1 to 8) see chart 4 on page A-24
- B** = 2 (for millions of screw revolutions)

Example 8:

Want to use the rolled 0.500 diameter by 0.500 lead preloaded ball screw in a 100 series table in a vertical application. Maximum speed is 20 inches/sec with an acceleration rate of 0.50 g's. What would the maximum estimated travel life of the screw (or end supports) be for a 45 lbs load?

- 1) From chart 4 - use a 4.0 safety factor (**S= 4.0**)
- 2) For vertical application:

$$F = 45 \text{ lbs}$$

- 3) From 100 series table section found dynamic screw capacity to be 1,980 lbs for 1 million inches of travel. The load capacity of the screw end support bearings at the 1 million inches of travel (1 / .500 = 2 million screw revs) is 1,145 lbs. Therefore use 1,145 (and not 1,980) to estimate life of the screw assembly.

- 4) Use the following equation to find L:

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

$$L = \left[\frac{1145}{45 \times 4} \right]^3 \times 2$$

$$L = 514,000,000 \text{ screw revs}$$

$$\text{or } \times 0.500$$

$$= 257,000,000 \text{ inches of travel}$$

Rotary Table Load Capacities

The static & dynamic load capacities of the bearing in a rotary positioning table far exceed those of the worm gear assembly. Therefore, the load/life of a rotary positioning table will typically be determined by the usable life of the worm gear. The life of the worm gear assembly is extremely difficult to determine. Lubrication, input speed, load weight, environment, duty cycle, and excessive side (moment) loads all affect the operating nature of the precision worm gear assembly. The gears will physically wear over time due to the metal to metal contact (high friction) of the worm gear assembly. Increase of backlash & input torque, along with a decrease in system smoothness & position accuracy are all symptoms of worm gear wear. However, in some situations these symptoms may not immediately affect the application. The same equation used for linear bearing & screw assembly life can be used to estimate the life of a worm gear driven rotary table. This is only an estimation and the true operating life will depend on how the rotary table actually needs to perform in a given application. The use of a proper safety factor will help estimate the life of a rotary positioning table.

Recommended Screw Drive Assembly Dynamic Safety Factors

Impacts or Vibration	Input Speed (rev/sec)	Duty Cycle (%)	Min. Safety Factor
None	< 10	< 30	1.0 - 1.5
Small	10 - 20	30 - 40	1.5 - 2.0
Medium	20 - 25	40 - 50	2.0 - 2.5
Large	> 25	> 50	2.5 - 3.0

Chart 5

The following equation can be used to help estimate the life of a rotary positioning table for a given load.

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

- L** = calculated travel life of table top (millions of revs)
- R** = rated dynamic load capacity of table top at 1 million revolutions (see specs in 300 - 400 series section)
- F** = user applied load
- S** = safety factor (1 to 3)
- B** = 1 (for millions of table top revolutions)

Example 9:

Application calls for a user load of 25 lbs. Maximum input speed is 10 rev/sec, with a duty cycle of 40%. Find the estimated life using a 300 series (90:1) rotary positioning table?

- 1) From chart 5 - use a 2.0 safety factor (**S= 2.0**)
- 2) From page J-5 for 300 series table specs:

$$R = 225 \text{ lbs}$$

- 3) Use the following equation to find R:

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

$$L = \left[\frac{225}{25 \times 2} \right]^3 \times 1$$

$$R = 91 \text{ million table top revolutions}$$

Structural Load Capacities

The load capacity of a positioning table structure is directly related to the material of the table, the I value (moment of inertia) of the table, and how the positioning table is mounted (supported or unsupported) to the user structure.

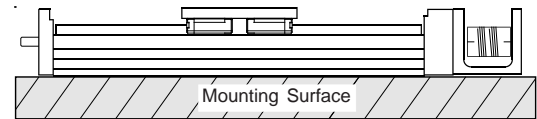
All standard *LINTECH* positioning tables are constructed using aluminum alloys. Aluminum is light weight, corrosion resistant, and quite stiff. All critical surfaces are precision machined to very tight tolerances, which produces a very accurate & repeatable positioning table. This includes table bases, linear bearing mounting surfaces, end plates, carriage assemblies, and other table support components.

The positioning table's I value (moment of inertia), the load, and the mounting configuration are main factors contributing to the deflection a table structure experiences for a given application. If a positioning table is fully supported over its entire length, and the proper safety factors for the linear bearing & drive mechanism are used, all standard *LINTECH* positioning tables will function properly. If a positioning table is mounted to a surface where the base is not fully supported, the table will experience a degree of deflection. If the deflection is too extreme, a positioning table will not function properly (usually binding occurs), and could fail outright. Increase of input torque required to move a load is usually the symptom encountered in applications with too much deflection.

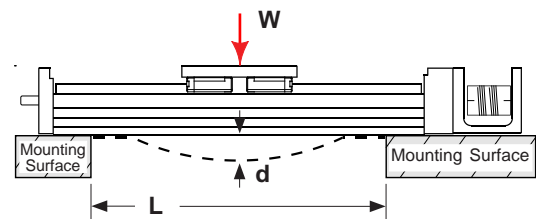
How much deflection is acceptable for a given table, mounted in a given configuration, is application dependent. For some high speed, screw driven applications too much deflection will cause the positioning table to stall.

Most positioning applications should have the table continuously supported by the user mounting surface. This helps to ensure trouble free operation. However, some applications call for end supported mounting configurations. The 100, 110, 120, and 130 series *LINTECH* positioning tables are widely used in end supported multi-axis applications where the "real world" deflection value may become a useful number. These numbers take into account deflections that cannot typically be calculated, such as multi-axis mounting hardware and table carriages. *LINTECH* provides these numbers in graph form in the respective table specification sections. These deflection numbers were actually measured and not calculated.

Below is deflection information on some of the more popular mounting configurations. It should be noted that the deflections shown are calculated, not actual. Actual deflection will also be a function of the user mounting surface and all hardware used to secure the positioning table to the surface.

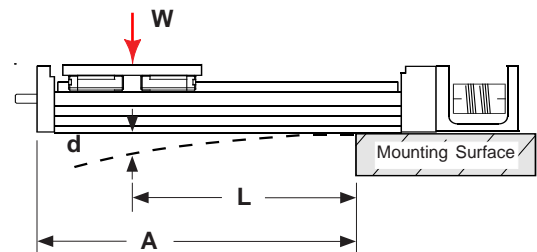


Continuously Supported



$$d = \frac{W \times L^3}{48 \times E \times I} + \frac{5 \times T \times L^4}{384 \times E \times I}$$

End Supported



$$d = \frac{W \times L^3}{3 \times E \times I} + \frac{T \times A^4}{8 \times E \times I}$$

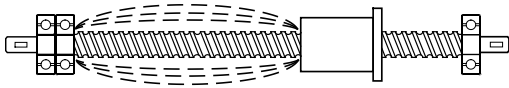
End Supported

- d** = deflection
- E** = modulus of elasticity
(aluminum = 10×10^6 PSI)
(steel = 30×10^6 PSI)
- I** = "moment of inertia" of table
- T** = weight of table per unit length
- W** = load weight

Maximum Speed

The maximum speed of a positioning table will either depend on the components of the bearing system or the drive mechanism assembly. Usually one or the other is the limiting factor. For **screw driven** linear positioning tables it usually is the screw assembly that limits its top speed. For **belt driven** linear positioning tables it is either the linear bearings, or the maximum belt force that limits the top speed. For rotary positioning tables it usually is the **worm gear** assembly that limits its top speed.

The maximum linear speed of a **screw driven** table depends on the screw diameter, length, lead, and end support housing configuration. For a given travel length increasing the screw diameter, or changing the screw lead can increase the positioning table linear velocity. This will come at the expense of increasing the torque required from the electronic motor/control system. *LINTECH* provides numerous screw options for each of its table series. The maximum speed information for all table travel lengths and optional screw combinations, is located in the individual table sections. Exceeding the maximum speed of a screw driven positioning table can cause a catastrophic failure, such as a deformed (bent) screw. This failure will more than likely produce a "rough running" system. Care should be taken to never exceed the maximum speed of a screw driven positioning table.



Maximum (critical) Speed

The maximum speed of a **belt driven** positioning table depends on the linear bearing system, and the forces the belt & pulley assembly can adequately handle. All of *LINTECH* belt driven tables use a recirculating square rail design for the linear bearings. The recirculating balls within the linear bearing block are moving at an incredible rate as the table moves. Exceeding the maximum speed of the linear bearings could cause the internal recirculating ball system to be damaged, which in turn could result in a rough running table or an outright failure. Before reaching these speeds however, the belt & pulley maximum force capabilities might be exceeded. The maximum linear forces that the belt can adequately handle are determined by the belt material, belt width, and the number of teeth on the pulleys. Exceeding the maximum belt force at a given speed will cause the belt to "skip" over the pulley teeth, thus causing mis-positioning of the table. Over time, continuous "skipping" of the belt over pulley teeth will weaken the belt, thus lowering the maximum belt force capability and maximum speed. Care should be taken to not exceed the maximum belt force capability. See the individual belt driven positioning table sections for information on the maximum speed of the linear bearings and the maximum belt & pulley force capabilities.

The maximum speed of a **worm gear driven** rotary table depends mainly on the worm gear assembly. The metal to metal contact of the worm gear will generate increasing heat as speed increases. If the speed (heat) gets too high, the worm gear will not only experience a great deal of wear, but also will require an increased amount of torque from the motor controller to move the table. The individual rotary table sections will list the maximum safe operating speed for a given rotary table.

Acceleration & Thrust Forces

As a positioning table starts motion with a given acceleration rate, a thrust force is generated ($F = MA$). This thrust force creates extra stresses on several components within a positioning table. Stresses are put on the linear bearing system, drive mechanism, carriage assembly, end plates, and the user mounting hardware.

The **maximum acceleration** rate for each table series is given in the individual technical sections. Exceeding this acceleration rate can cause immediate damage to a positioning table's components and should be avoided. An excessive acceleration rate can cause the recirculating ball network within the linear bearings (and/or a ball screw) to fail catastrophically. In a belt driven table, too high an acceleration rate can cause the belt to "skip" over the pulleys. This will cause the table to mis-position and can damage the belt. Maximum belt force capacity for a given belt driven positioning table is located in the individual table sections. Care should be taken to never exceed the maximum acceleration rate for a given table series.

In a perfect world, the axial thrust force ($F=MA$) created during the acceleration portion of a move should be added to the normal applied load a linear bearing (or screw assembly) sees. During the deceleration portion of a move, the axial thrust force would be subtracted from the normal applied load. Since these move distances are usually so short, and the fact that the increase in axial force during acceleration is offset by a reduction of axial force during deceleration, these forces are generally ignored. However, the shock load created during accel/decel intervals should not be ignored. Therefore, use the proper safety factor for acceleration when estimating the life of a linear bearing & screw drive mechanism.

Potential Thrust Forces

Screw & belt driven linear positioning tables are not normally thrust producing devices. They are not designed with the thought of producing thrust forces. However, that does not mean that they do not have the capability of producing a thrust force via an attached motor. The following equations convert rotary torque available from a motor into a linear axial thrust force. These become useful for those positioning applications that also require the table to generate a set amount of thrust.

Screw Driven Table

$$C = \frac{2\pi e (T_M - T_T)}{d} \frac{\text{lb}}{(16 \text{ oz})} \quad (\text{lbs})$$

Belt Driven Table

$$C = \frac{g e (T_M - T_T)}{r} \frac{\text{lb}}{(16 \text{ oz})} \quad (\text{lbs})$$

- C** = potential axial thrust force (lbs)
- d** = screw lead (inches)
- e** = efficiency of screw or gearhead (90% = .9)
- g** = gearhead ratio (5:1 = 5)
- r** = radius of drive pulley (inches)
- T_M** = available motor torque at operating speed (oz-in)
- T_T** = torque required to move load (oz-in)

Example 10:

Application calls for a ball screw driven horizontal application with a 0.200 inch lead. Motor sizing has yielded torque requirements as follows: acceleration = 100 oz-in, constant speed = 20 oz-in, and deceleration = 80 oz-in. The maximum motor torque output at the desired speed is 250 oz-in. Find what axial thrust force is available for each move segment.

accel portion:

$$C = \frac{2\pi \cdot 9 (250 - 100)}{.2} \frac{\text{lb}}{(16 \text{ oz})} = 265 \text{ lbs}$$

constant speed portion:

$$C = \frac{2\pi \cdot 9 (250 - 20)}{.2} \frac{\text{lb}}{(16 \text{ oz})} = 406 \text{ lbs}$$

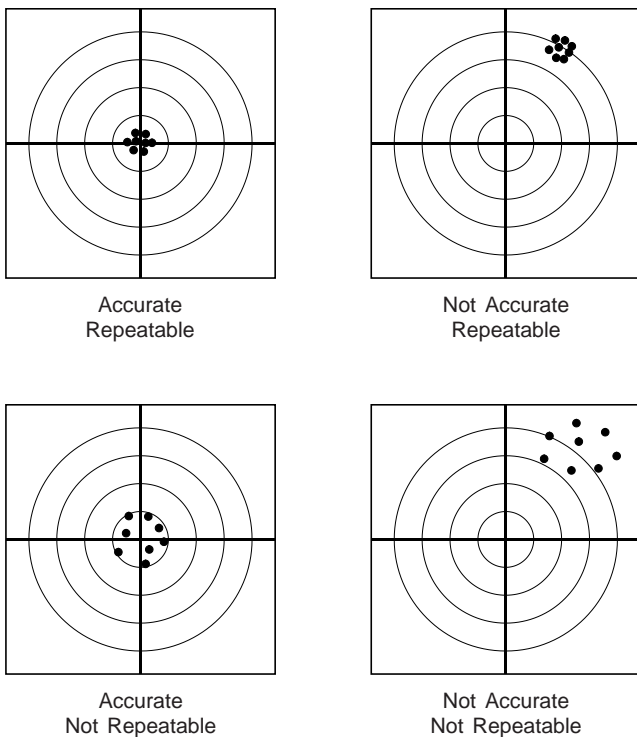
decel portion:

$$C = \frac{2\pi \cdot 9 (250 - 80)}{.2} \frac{\text{lb}}{(16 \text{ oz})} = 300 \text{ lbs}$$

Accuracy

The difference between accuracy and repeatability is widely misunderstood. Accuracy in a positioning system is much harder to achieve than repeatability, and it is also more expensive to accomplish. Applications like *part INsertion*, *pick & place*, and *simple INspection stations* require good repeatability, not necessarily accuracy. Why? Because once you have programmed the electronic motion controller & mechanical positioning table to position a load to a given location, you are typically more concerned as to how well the system can return to that location. Repeatability of the overall system becomes important for the application. The inaccuracies in the above systems can be offset by instructing the electronic motion controller to move a little bit more, or a little bit less. On the other hand *microscope XY INspection stands*, *semiconductor wafer probING machINes*, and *coorDINate measurING machINes* require both good repeatability and high accuracy. Why? Because for these applications to be successful, they need to be very accurate (in the truest sense) when making a move from one location to another. Many positioning system applications in the real world require high repeatability, not necessarily high accuracy.

Accuracy is described as how well a positioning system makes a true relative move in reference to an absolute 3D location. In essence, if we lived in a perfect world, when a positioning system makes a 1.0 inch (25.4 mm) move, it truly moves 1.0 inches (25.4 mm). However, there are mechanical errors associated with every positioning system. These errors will cause the positioning system to be less than perfect when making moves. Move distances that will be something different than what were truly desired.



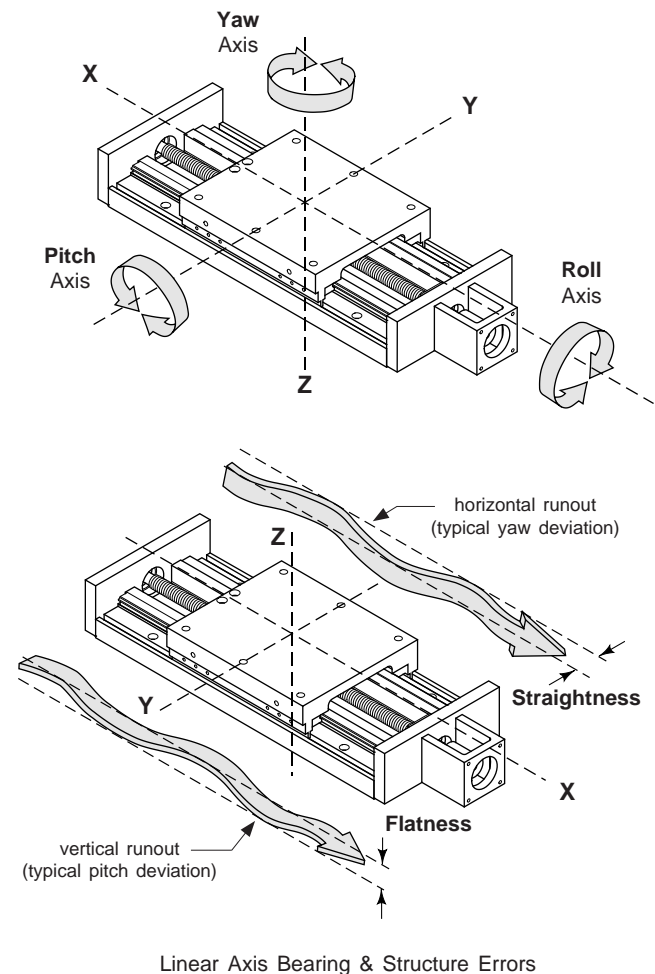
Instead of providing you with an in-depth discussion on each of these errors, we would like to give you just a little insight on each. Understanding that these errors exist will help you realize that every positioning system manufactured will exhibit some, or all, of these errors. Even systems you design yourself will have inaccuracies associated with it. **LINTECH** takes many steps to minimize these errors in our positioning tables, thus providing you with a cost effective, accurate, and repeatable positioning system.

Linear bearing & structure inaccuracies include:

- * angular (roll, pitch, & yaw)
- * vertical runout (flatness)
- * horizontal runout (straightness)

Some of the sources of these errors are:

- * straightness of the linear rail
- * entry & exit of recirculating balls in the linear bearings
- * variation of the preload when moving along the rails
- * contaminants between linear bearings & rails
- * machining of the rail mounting surface on the table
- * machining of the base, carriage, and other components



Accuracy - Continued

Linear bearing & structure inaccuracies will cause a positioning system to move something other than what is desired. *LINTECH* includes these errors in the overall "Position Accuracy" value described below. *LINTECH* also provides flatness & straightness specifications for each table series. These values can be used as a general gauge to the overall linear bearing & structural quality of a positioning table. The better these values are, the better the accuracy & repeatability of the positioning table will be.

Inaccuracies in the linear drive mechanism of a positioning table also contributes to its overall position accuracy. *LINTECH* provides acme screw, ball screw, and belt driven linear positioning tables.

Linear drive mechanism sources of errors include:

- * lead error of the screw
- * end support mounting of the screw
- * nut and screw quality & wear
- * lead error of the belt
- * belt stretch
- * end pulley quality & alignment

The lead error of the belt, or screw is a main factor affecting the accuracy of a positioning table. It is important to realize that these inaccuracies are not linear. These errors in fact are non-linear, and their value is typically given in the form of inches/foot (microns/300 mm).

Position accuracy is a value given by *LINTECH* for each single axis table series that can be used to estimate what the potential accuracy (or inaccuracy) will be for any given travel. Because *LINTECH* provides many different acme screw, ball screw, and belt drive options, along with many different standard table travel lengths, this position accuracy value is given in the form of inch/ft (microns/300 mm). This allows you to quickly estimate what the position accuracy might be for a given table series, linear bearing, drive screw (or belt), and travel length.

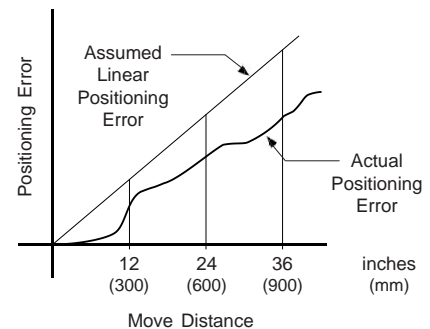
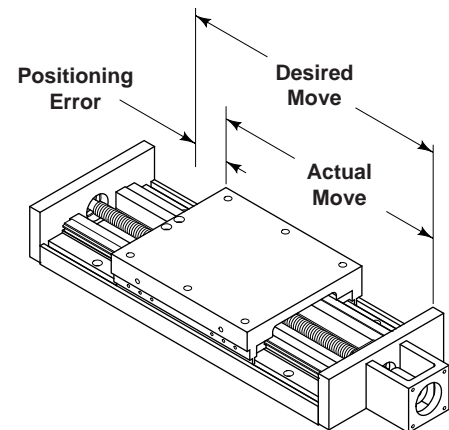
The key here is to realize that position accuracy is an estimation. Typically, no two positioning tables (even though they are manufactured with all the same components) will exhibit exactly the same position accuracy throughout their entire travels.

Testing (or mapping) of a given positioning table could be performed to determine what the true accuracy is over each inch of travel for a given system. However, this testing should be performed with the positioning table mounted in the user's application with all loads attached to the carriage. Position accuracy of a system can change based upon mounting surfaces, loads, and environment conditions which includes temperature.

For both screw and belt driven tables position accuracy is not a linear relationship. In fact, all the error within any 12 inch (300 mm) segment of travel could occur in say just 2 inches (50 mm). Also, the value in/ft error is a maximum (no worse than) value. Some 12 inch segments could have a value better than the stated position accuracy. Following is an example of the potential position accuracy for a given table.

* 48 inch travel table with a 0.003 in/ft position accuracy

Travel Length (inches)	Actual Error (inches)	Error Occurred Between (inches)	Total System Error (inches)
0 to 12	.002	2 to 5	.002
12 to 24	.001	7 to 9	.003
24 to 36	.003	1 to 6	.006
36 to 48	.001	4 to 11	.007



Accuracy - Continued

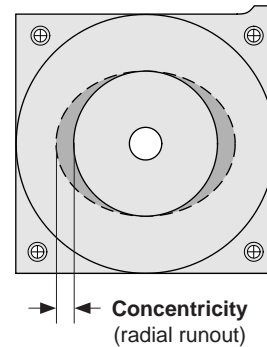
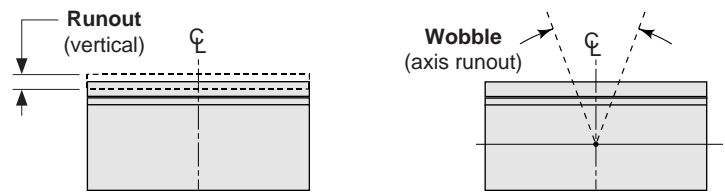
Rotary positioning table accuracies deal with the bearings that carry the load, the worm gear used to drive the load, and all associated precision machined components.

Runout is defined as the vertical deviation (inches or mm) measured throughout one full rotation of the table top. The 300 series rotary table has a precision option that provides a smaller runout deviation over the standard unit.

Wobble (axis runout) is defined as the angular variation from the true centerline of rotation throughout one full rotation of the table top. The 300 series rotary table has a precision option that provides a smaller angular variation over the standard unit.

Concentricity (radial runout) is defined as the deviation (inches or mm) between a perfect circle and the path the table top takes throughout one full rotation of the table top. The 300 series rotary table has a precision option that provides a smaller radial deviation over the standard unit.

Position accuracy of a rotary table is directly related to the precision machined worm gear assembly. The arc-second accuracy value is not dependent upon gear ratio. However, over time (wear of the worm gear) the accuracy can change depending upon the application.



Rotary Axis Errors

Repeatability

The repeatability of a positioning system is defined as how accurate, over successive move attempts, a table can return to a known, previously traveled location. The direction of travel can either be from one side (unidirectional), or from both sides (bidirectional). Highly repeatable systems (which may or may not be accurate) return to a known location with very little deviance from one move to the next.

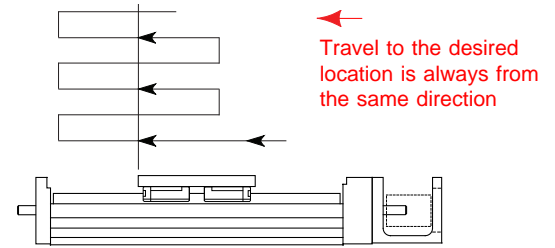
The bearings, table structure, operating environment, table orientation and the drive mechanism all play a part in the repeatability of a positioning table for a given application. Mounting high quality precision bearings to a precision machined table structure will help make a positioning system more repeatable. Operating a positioning table in an environment that has wide swings in temperature (and/or large vibrations), will adversely affect the repeatability of a system. Mounting a table in a vertical orientation has the benefit of eliminating (with no reversing force) backlash.

The drive mechanism can (and will) influence the repeatability of a positioning table. Using a higher accuracy grade screw for example will typically yield a better repeatability for the system. Besides playing a part in the unidirectional repeatability of a table, it can have a larger impact on the bidirectional value by dealing with backlash. Backlash in a **belt driven** positioning table consists of stretching, wear and tension of the belt, along with the individual manufacturing tolerances of the belt & pulley assembly. Backlash in a belt driven table is virtually impossible to eliminate. Backlash in a **screw driven** positioning table can be eliminated by using a preloaded nut assembly, thus the unidirectional & bidirectional repeatability will be the same. For applications requiring good bidirectional positioning, a preloaded nut assembly should always be used. Backlash in a worm gear assembly is also virtually impossible to eliminate. Therefore, to maintain a high level of repeatability, approach a known location from the same direction.

It should also be noted that the overall repeatability of a positioning table within a given application is highly dependent on the electronic motor/drive controller.

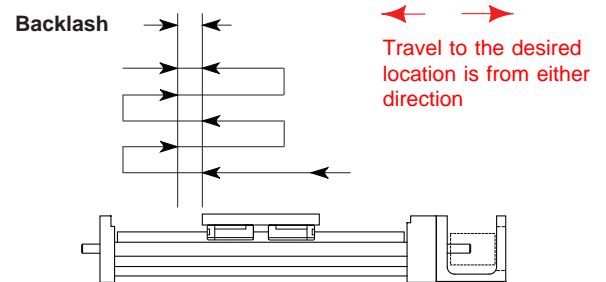
The majority of applications require a highly repeatable positioning system, and not necessarily an accurate one. Therefore, more attention should be given to the repeatability specification of a table than position accuracy.

Horizontal Applications - Unidirectional Repeatability



Horizontal Applications - Bidirectional Repeatability

(Unidirectional Repeatability + Backlash)



Vertical Applications (No reverse force)

Bidirectional Repeatability = Unidirectional Repeatability

Reverse Force

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

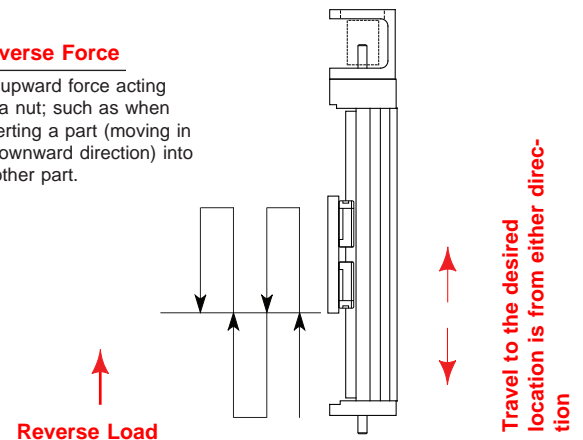
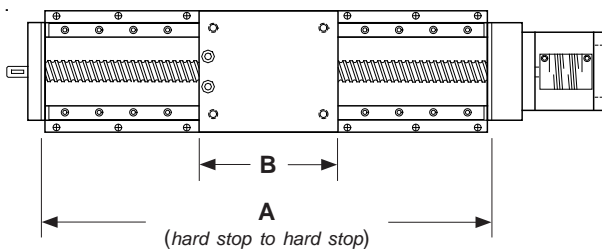


Table Size

The physical size of a positioning table can play a major role in the selection of a proper table for a given application. Besides the obvious height & width parameters of a positioning table, care should be given to the selection of the correct carriage size and travel length.

In most cases *LINTECH* provides **several carriage** options for a given table series. The carriage can be provided in either a 2 or 4 bearing version, with English inserts, Metric inserts or T-slots for load mounting. The 4 bearing carriage on some table series uses the same length carriage, while on others the length of the carriage is increased. In light (low moment) load applications using a 2 bearing carriage over a 4 bearing provides a cost savings. In applications where deflection of the attached user load is of concern, it is recommended that a positioning table with a 4 bearing carriage be selected, even though a 2 bearing carriage could handle the load/life requirement. While 2 bearing carriages offer a cost savings, 4 bearing carriages provide a much more rigid system. Therefore, for any moment load or high speed screw driven applications, four bearing carriages are recommended.

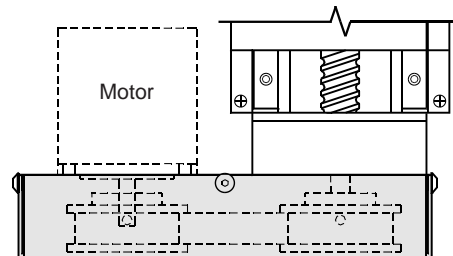
Selecting a positioning table with a **travel length** that is greater than what is required for an application is also recommended. *LINTECH* tables have their travel lengths rated "hard stop" (end plate) to "hard stop" (end plate). Therefore, when "end of travel" & "home" switches are used, the actual travel of the positioning table carriage is something less than the rated travel length. Also, when using a high speed drive mechanism, such as a high lead ball screw or belt drive, deceleration distance of the load should be considered. The position of the EOT (limit) switches must be placed so that the activation of a switch allows for sufficient distance to decelerate the carriage prior to contacting (hitting) an end plate (hard stop). Contacting the positioning table end plates will cause an impact load which increases with the speed of the impact. Having extra travel length to account for these distances, can help make for the successful selection of a positioning table for a given application.



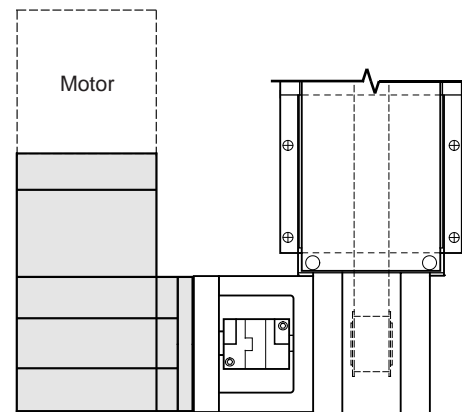
$$\text{Travel Length} = A - B$$

(specification)

The **motor wrap** option that is offered for every screw driven table series allows the attached motor to be mounted parallel (along side) a positioning table. This will decrease the overall positioning system length, while increasing its width. The normal motor mount bracket is replaced with a zero backlash belt & pulley assembly. For belt driven positioning tables, using a right angle gearhead has the same effect of locating the motor along side the table.



Screw Driven Table with Motor Wrap



Belt Driven Table with Right Angle Gearhead

Lubrication

Every *LINTECH* positioning table requires grease or oil for proper, long-term operation. Lubrication will dissipate heat, reduce friction, decrease system wear, and aids in preventing oxidation (rust) to those positioning table components that require protection. For most applications, a medium to heavy oil, light grease, or silicone based lubricant is recommended. The frequency of lubrication will ultimately be determined by the system application and table environment. Lack of lubrication could prevent a positioning table from reaching its normal expected (or calculated) life.

The many built-in pockets within the **linear bearings** that *LINTECH* uses, will allow the adhesive properties of most lubricants to be stored, and used by the recirculating balls for extended periods of time. Thus, as the positioning table moves back & forth, lubrication is applied to the linear rails. Most of the linear bearings have a lube port located on the bearing block (or carriage assembly) which allows for easy access to add lubricants.

Because **acme screw & turcite nut** screw driven positioning tables have a solid surface contacting a solid surface, sufficient lubrication becomes a must. If there is not proper lubrication, the high frictional forces of these nuts will cause excess wear to the assembly, thus preventing required positioning table life from occurring. Applying lubrication directly onto the entire length of the screw on a regular basis is highly recommended.

For **ball screw** driven positioning tables, the many built-in pockets within the nut assembly will allow the adhesive properties of most lubricants to be stored, and used by the recirculating balls for extended periods of time. Thus, as the positioning table moves back & forth, lubrication is applied to the ball screw. The nut assembly will pick up grease, or oil that is spread over the entire length of the screw. Therefore, applying lubrication directly onto the entire length of the screw on a regular basis is recommended.

High speed applications should NEVER have the linear bearings (or screw assembly) operate dry for any length of time. These applications can use grease or oil type lubrication. Grease is the preferred type since grease stays on the linear bearing rails & screw for longer periods of time. However for 24 hours a day, 7 days a week continuous operating applications, an automatic oil lubricating system may be required. For some low speed and lightly loaded applications, a linear bearing (and ball screw) assembly may be operated without lubrication. However, 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 linear bearings & drive screw nut.

Screw end support bearings and **belt pulley bearings** are sealed. Therefore, no lubrication is required for these components.

The **300 series rotary table** should have a lithium soap based grease #1 added to the worm gear assembly if the control system, or user, observes either an increase of input torque or a rough running table. These tables are equipped with a check-ball type grease fitting that supplies lubricant to the precision worm gear. Even though the rotary angular contact bearing is not completely sealed, the amount of grease packed into the assembly during manufacturing is sufficient for the life of the table.

The worm gear assembly and rotary bearing on the **400 series table** is not sealed. However, for most applications the grease which is packed into the assemblies during manufacturing is sufficient for the life of the table. Therefore, no lubrication is required.

Mounting Considerations

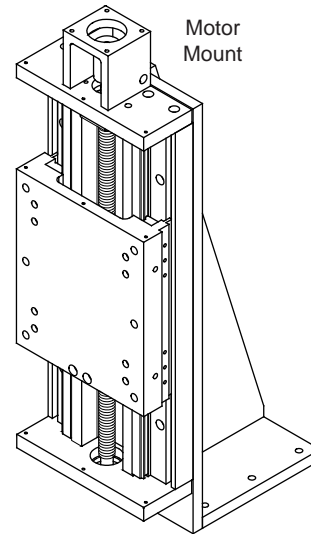
In order to achieve the published position accuracy & repeatability specifications of a *LINTECH* positioning table, care must be taken in mounting the table to the user surface. The mounting surface for the positioning table must be as flat, or flatter, than the positioning table itself (see flatness specification in individual table sections). If the surface is not, "shimming" will be required to achieve the published accuracy & repeatability specifications. Preparing the mounting surface properly ahead of time can prevent "shimming" later.

If possible, provide a mounting surface that supports the table over its entire base. This will minimize the potential for structural deflections as the load travels over unsupported regions. Deflections of the positioning table (and load) will occur for end supported mounting configurations. Too much deflection can cause the positioning table to bind or operate rough. (see page A-27). Use all of the **base mounting** holes (or as many as possible) to attach the table to the surface. Custom base mounting hole patterns are available upon request.

Positioning **table carriages** are either provided with stainless steel inserts (English or Metric threads), or with a T-slot for mounting of the user load. These carriages should not be modified or disassembled by the user. Special tools, equipment, assembly surfaces, and certain procedures are adhered to during the manufacturing of each positioning table. Dismantling of the carriage assembly from the table could alter the performance of the positioning table upon reassemble. It is recommended that an adapter plate be provided between the load and the carriage surface if the steel inserts (or T-slot) cannot be used directly. Custom carriage interfaces can be provided upon request. Also, the use of all the available carriage mounting holes for securing the load, helps minimize unwanted deflections and increase system rigidity. The moment load ratings within this catalog for a particular positioning table are based upon all the carriage inserts (and as many T-nuts as possible) are utilized to secure the load to the carriage.

For **vertical belt driven applications** there is no preference for the motor mount location. The motor mount can be located at the top or bottom of the positioning table. Due to the high efficiency of the belt drive mechanism a power-off brake is recommended. See page A-40.

For **vertical screw driven applications** it is recommended that the motor mount end of the positioning table be located up (above the carriage). This puts the screw assembly in tension as the fixed screw end support is located on the motor mount end. Mounting the table with the motor mount located on the bottom will put the screw assembly in compression. Having the screw assembly in tension (which is a load trying to stretch the screw) is preferred over a screw assembly in compression (which is a load & screw shaft weight trying to buckle the screw). Contact *LINTECH* for vertical applications requiring the motor mount to be located on the bottom of the table.



Vertical Axis (screw in tension)

Standard *LINTECH* positioning tables are designed to accept either an optional NEMA 23, 34 or 42 **motor mount** with either an English or Metric mounting interface. Metric (or other) motor mount options are available upon request. Some motor mounts could extend above and/or below a particular positioning table base. Preparing the user mounting surface ahead of time to deal with this extension could prevent frustration later. *LINTECH* has several available motor mount brackets which are designed for use with the optional motor couplings. The motor mounts and couplings are designed to fit within a given envelope. Each table series section lists the coupling dimensions that fit within a given motor mount. Care should be taken by the user when supplying their own motor bracket and/or coupling. Some "third party" couplings do not fit within some standard *LINTECH* motor mounts.

Some power-off brake, incremental encoder, or motor wrap options can extend above and/or below a particular table series base and/or increase the table width. Preparing the user mounting surface ahead of time to deal with these extensions is highly recommended.

Motor Couplings

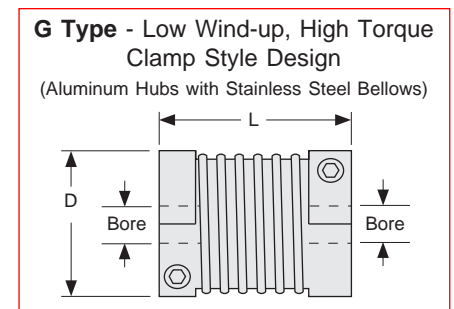
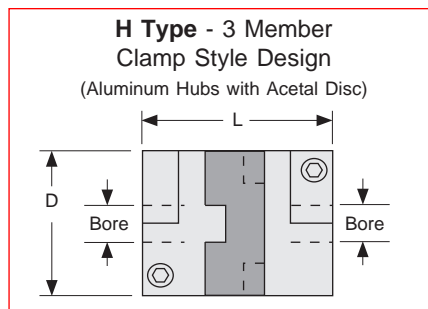
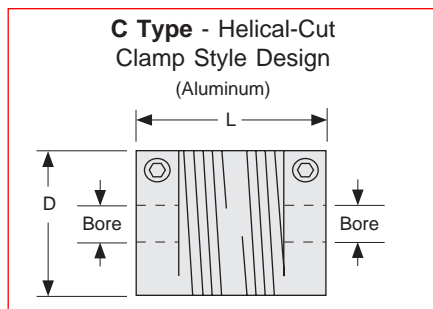
The main function of a coupling is to transmit the power generated by the attached motor to the screw, belt, or worm gear drive assembly. *LINTECH* provides three different types of couplings that can be used to attach a motor shaft to a positioning table. These couplings will compensate for some misalignment between the motor & table shafts. This provides for trouble-free operation as long as certain precautions are taken. First, the connected motor output torque should never exceed the coupling maximum torque capacity and a proper safety factor should be used. Second, select the proper coupling for a given application (see the charts below).

These couplings are typically not limited by speed, but they can be damaged (or weakened) over time in certain situations. Some of the more common situations are hitting a hard stop (or the positioning table end plates), servo systems that are tuned incorrectly, high acceleration rates, large back-driving vertical loads, use of gearheads, and moving large inertia loads. All of these situations should consider the use of a coupling with an adequate safety margin between

the coupling torque rating and the maximum motor (or gear-head) output torque. The main differences between the three couplings are wind-up (twist or torsional compliance), torque capacity, and cost. The chart below lists how the three types of couplings compare to each other.

When a coupling is subjected to torque it will twist. The amount of twist (deflection) for a given torque is wind-up. The higher the wind-up value of a coupling, the greater the "spring action" the coupling will exert between the motor & table shafts. This "spring action" can cause a high performing servo system to become unstable. Therefore, for servo motor applications a "G" or "H" style coupling with a low wind-up value should be considered.

LINTECH provides various diameter & length sizes for the "C", "H", and "G" style couplings. Each of these couplings are provided with an assortment of bore diameters to accommodate various NEMA & metric motor shafts. The individual sections will list all the coupling data available for a given table series.



Coupling	Cost	Torque Capacity	Wind-up	Suggested Motor	Comments
C Type	least expensive	light	the most	stepper	ideal for most step motor applications
H Type	medium priced	medium	medium	stepper or servo	use for high accels & for starting & stopping large inertia loads
G Type	most expensive	high	the least	servo	use for very high torque requirements & very high servo accelerations

Recommended Coupling Maximum Torque Safety Factors

Impacts or Vibration	Speed (revs/sec)	Acceleration (G's)	Min. Safety Factor
None	< 2	< 0.10	1.8 - 2.0
Small	2 - 10	0.10 - 0.50	2.0 - 2.2
Medium	10 - 20	0.50 - 0.75	2.2 - 2.4
Large	20 - 50	0.75 - 1.00	2.4 - 2.6
Very Large	> 50	> 1.00	2.6 - 3.0

EOT (end of travel) & Home Switches

LINTECH provides several options for EOT & home switches for use on its positioning tables. One style uses mechanically actuated switches, while other styles use "non-contact" versions. Each switch is mounted to the base of the table, while the actuation cams are mounted to the carriage (or table top) assembly. The switches can be pre-wired by LINTECH for easy interfacing to the users electronic motor controller.

Linear positioning table **EOT (end of travel)** switches can be utilized by a motion controller to stop carriage motion, thereby preventing any damage to personnel, carriage, or user mounted load if the extreme end of travel has been reached by the carriage. There are two EOT switches mounted to the base of the table, one on each end. The CCW switch is mounted at the motor mount end, while the CW switch is located at the opposite end of the table. LINTECH provides normally closed (NC) end of travel switches. This provides for a fail-safe system, where the position controller can detect broken wires. *It is highly recommended that any positionING table used with a position controller, should have end of travel switches INSTALLED for protection of personnel, table carriage, and user mounted load.*

The **home switch** can be utilized by a motion controller as a known fixed mechanical location on the positioning table. For linear positioning tables the switch is located near the motor mount end and is a normally open (NO) switch.

The **mechanical switch** option is reliable, repeatable, and does not require a power supply. The **reed switch** option is an inexpensive, non-contact, magnetically actuated solution for low repeatable applications that also does not require a power supply (ideal for belt drive applications). The **hall effect** switch option requires a +5 to +24 VDC power supply, but is a non-contact, magnetically actuated device which is repeatable. The **proximity switch** option is a non-contact, non-magnetic actuated device that requires a +12 to +24 VDC power supply. This option has a long activation area that can also be provided in either an NPN or PNP switch version. It is not possible to take a NPN switch and rewire it to be used as a PNP switch, as the NPN switch is internally different than a PNP switch.

Some table series have the switches located inside the positioning table, thus there is no additional width to the table. Other table series have the switches located along the side of the positioning table. In some cases there will be a slight increase in table width. See the individual table sections for information on EOT & home switches.

Switch Type	Cost	Repeatability inches (microns)	Actuated	Power Supply Required	Activation Area inches (mm)	Comments
mechanical	least expensive	+/- 0.0002 (5)	mechanical	No	1.75 (44,45)	for most applications
reed	slightly more	+/- 0.0020 (50)	magnetic	No	0.30 (7,62)	for non-contact & low repeatable applications
hall effect	medium priced	+/- 0.0002 (5)	magnetic	Yes	0.32 (8,13)	for non-contact and wash down applications
proximity	most expensive	+/- 0.0002 (5)	non-magnetic	Yes	1.75 (44,45)	for non-contact, high speed, & wash down applications

Note: The repeatability of any switch is dependent upon several factors: carriage speed, accel rate, load weight, switch style, and the position controller. LINTECH's ratings are based upon a carriage speed of 0.5 inches/sec (12.7 mm/sec) and a no load condition.

Encoders

Linear and rotary incremental encoders can be mounted to most *LINTECH* positioning tables. These encoders provide a differential square wave A, B and Z (marker pulse), TTL signals (+ 5 VDC) that are compatible with most motion controllers.

Linear encoders can be mounted along side any screw driven positioning table. These incremental encoders are provided in either an English resolution (i.e. 0.0001 inch/pulse) or a Metric resolution (i.e. 1 micron/pulse). The encoder precision etched glass scale is packaged in an aluminum housing, which is mounted to the table base (or end plates) and is protected with seals (IP53) over the entire length of travel. The encoder read head is mounted to the table carriage and is supplied with a high flex, shielded 10 foot (3 m) cable that is terminated to a 12 pin DIN connector. There is a mating DIN connector supplied for easy wiring to the motor control system. The linear encoder option is ideal for those applications where closed loop positioning is required. The attached motor (stepper or servo) & controller will move the table until a set amount of encoder pulses has been recorded by the position controller. The process of positioning to the encoder (closed loop) in an application, eliminates positioning problems due to screw lead errors, coupling wind-up, mechanical backlash, and unexpected motor stalls. In order to position to 1 pulse of an encoder the motor/screw resolution needs to be 4 times greater than the encoder resolution. For example:

- * using a 0.0001 inch/pulse encoder
- * with a 0.200 inch/rev ball screw
- * requires motor/controller with minimum resolution of:

$$\frac{.200 \text{ in}}{\text{rev}} \times \frac{\text{pulse}}{.0001 \text{ in}} \times 4 = 8000 \text{ pulses/rev}$$

This resolution ratio of the motor/drive/table versus encoder will help prevent "dithering" over 1 encoder count. In some cases, positioning to a specific encoder count location may not occur due to table friction (stiction), screw accuracy grade, applied load, wind-up in a coupling, motor output torque, and tuning of a servo system among others. By using a well lubricated system, high accuracy grade screw, coupling with minimal wind-up, and a high resolution motor/drive controller will help ensure success. It should be noted that using a linear encoder does not always increase the positioning table accuracy to that of the linear encoder. Even though the linear encoder can compensate for the lead error of a screw, it cannot compensate for straightness, flatness, and angular errors of the table bearings and structure. Also, cosine errors (misalignment of encoder to direction of travel) and Abbe errors (offset distance between encoder read head & carriage top) will play a large factor on overall linear positioning accuracy.

Even though these linear encoders can operate at a maximum speed of 79 inches/sec (3 m/sec), installing them on a belt driven positioning table is not recommended. The motor/table to encoder 4:1 require resolution ratio is difficult to achieve due to the belt drive lead (3.5 inch/rev). This means that in most applications the motor controller will try to position to an encoder pulse that it never can reach, thus encoder "dithering". Even if it were possible to get to a 4:1 resolution ratio, the inaccuracies & stiction of the belt & pulley system could also cause encoder "dither".

Linear encoders with different resolutions, or special linear encoders for high temperature, vibration, and environmental challenging applications are available upon request.

Rotary encoders can be mounted to any screw or belt driven positioning table. These incremental encoders are provided in resolutions of 500, 1000 and 1270 lines/rev. The encoder precision etched glass disk is mounted to the screw, or belt & pulley, shaft extension and has a plastic protective cover. The shielded 10 foot (3 m) cable can easily be connected to most motion controllers or digital position displays. Positioning to a rotary encoder will compensate for errors in coupling & gearhead components. However, rotary encoders will not compensate for linear positioning errors within the screw & belt drive mechanisms. Rotary encoders are ideal for applications where an operator requires positional data via a digital display, or where detecting the stall of a carriage assembly is important.

See the individual table sections for linear & rotary encoder specifications, wiring information and mounting orientation.

Power-Off Brakes

For vertical positioning table applications, or for those applications requiring the load to be locked securely in place, an electric brake may be mounted to the table. Screw driven tables will have the brake mounted to the screw shaft extension located on the table end opposite the motor mount bracket. Belt driven tables will have the brake mounted to the thru drive shaft option. With proper wiring from a control system, this power-off friction brake can ensure that the carriage is firmly held in place when no electric power is applied to the brake. When power is applied to the brake, the brake is opened or "released".

Acme screws, with their inherent high frictional forces, do not usually back-drive. Therefore, they are ideal for vertical applications. When motor power is removed, the acme screw will usually hold the user load in place. Therefore, a power-off brake is usually not required. However, for applications experiencing a large amount of vibrations, it is not uncommon to see a brake mounted to an acme screw driven table. These external vibrations could cause the acme screw nut (carriage) to creep, or move unexpectedly.

Ball screws are ideal for long life, high speed vertical positioning applications. However, because of their high efficiency, when motor power is removed, the user mounted load can force the positioning table to back-drive. Damage to surrounding equipment, or personnel can occur. Therefore, it is highly recommended that a power-off brake be installed to the positioning table. By applying the brake to the screw shaft when motor power is removed, the carriage (load) will firmly be held in place as long as the applied force does not exceed the rating of the brake.

Belt driven positioning tables are also ideal for some high speed vertical applications. The belt drive design provides for a very efficient system. Thus when motor power is removed, the user mounted load can back-drive very rapidly, causing a potentially dangerous situation. The use of a power-off brake should always be installed in these situations. The power-off brake is also recommended in those horizontal applications where an external force can move the carriage due to the highly efficient belt & pulley drive system.

The brake comes with two wires for power (24 or 90 VDC). Any DC power supply with ample current output can be used to power these brakes. *LINTECH* does provide 4 different optional power supplies that are designed for use with power-off brakes. The wires should be directly connected to an external power supply, or user supplied relay network. For proper emergency braking of the positioning table, this electric brake needs to be interfaced to a position controller or relay network. In most cases, your motor drive and brake power should come from the same source, thus when the drive loses power, so will the brake. For stepper & servo systems, further interfacing is required to ensure power-off braking occurs if a motor stalls or there is a drive fault. For step motor systems, the addition of an encoder in the system can help detect system stalls, which can then engage the brake and prevent back-driving of the load. Servo systems usually have some sort of fault signal output which can be used to engage the brake in the case of a system stall.

This power-off electric brake SHOULD NOT be engaged when the positioning table is in motion. Moving the table with the brake applied could damage the brake and the positioning table. Also, continuous use of this brake to stop a table (load) that is in motion could damage the brake and the positioning table. Dynamic braking of a positioning table should be done by the motor and not the brake. On some complete system "power up" situations, it may be necessary that power to the brake be delayed several seconds over the power which is applied to the motor/control system. This allows time for torque to be built up in the motor/control before the brake is released, thus potentially preventing the load from falling on total system power-ups.

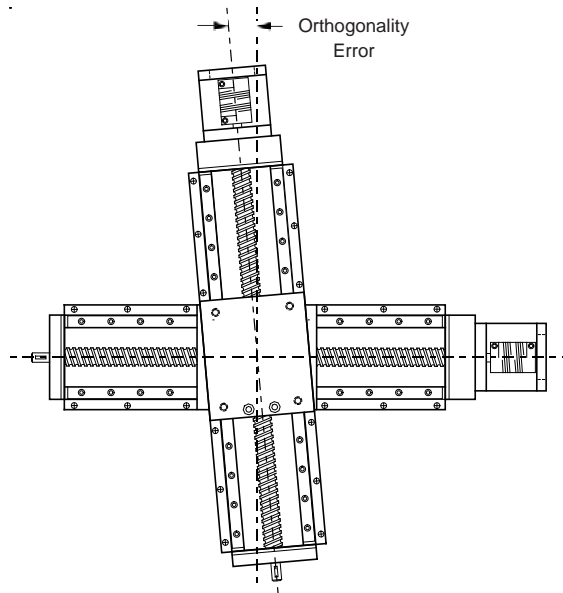
See the individual table sections for power-off brake mounting orientation and dimensions.

Brake Model Number	Holding Force in-lbs (N-m)	Excitation Voltage volts	Current amps	Weight lbs (kg)
B01	18 (2,0)	24 VDC	0.733	1.4 (0,62)
B02	18 (2,0)	90 VDC	0.178	1.4 (0,62)
B03	84 (9,5)	24 VDC	0.973	3.3 (1,50)
B04	84 (9,5)	90 VDC	0.239	3.3 (1,50)
B05	180 (20,3)	24 VDC	1.136	4.5 (2,04)
B06	180 (20,3)	90 VDC	0.287	1.4 (2,04)

Multi-Axis

LINTECH has manufactured numerous multi-axis positioning systems for use in a wide variety of applications. X-Y, X-Z, and X-Y-Z multi-axis systems can be created in a variety of ways. *LINTECH* offers base to carriage, carriage to carriage, the use of horizontal & vertical angle brackets, and the integration of different table series to create various multi-axis positioning systems.

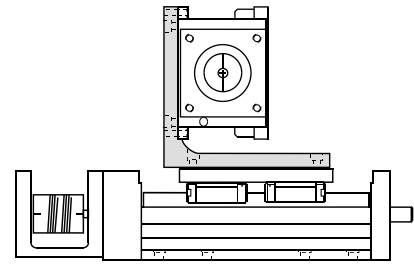
The most common X-Y mounting configuration is obtained by stacking two single axis tables on top of each other. The base of the top (Y axis) is mounted to the carriage of the bottom (X axis). Any time a multi-axis system is created by stacking of tables, the bottom axis (or axes) will have several application considerations that need to be reviewed. First, the bottom axis will experience moment loads that are generated by the top axis moving. These moment loads will vary, and the mean load equation on page A-19 can help to determine the forces exerted on the bottom axes bearings. For the majority of applications, a 4 bearing carriage should always be considered for any bottom axis. Second, additional errors are introduced into the system, such as orthogonality and stack up errors. Orthogonality is the maximum deviation from perpendicularity between 2 axes. Stack up errors are angular errors transmitted from the bottom axes to the top axis.



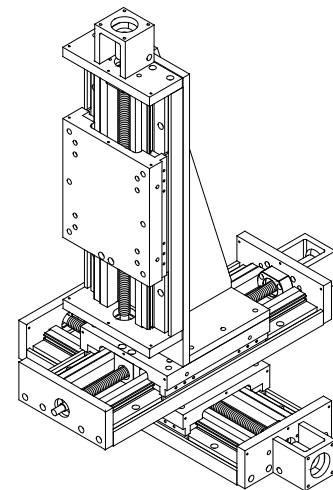
X-Y Axis Orthogonality

Another X-Y mounting solution has a spread rail configuration mounted to a base plate for the X axis. This generates more uniform forces on the bottom axis bearings, while also minimizing system deflections.

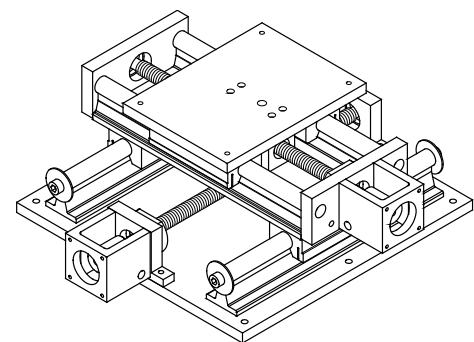
Some standard table series within this catalog can easily be constructed into a multi-axis arrangements. The 100, 110, 120, 130, 170, 180 and 550 either have base & carriage mounting hole patterns that match each other, or a selection of adapter plates & angle brackets that make creating a multi-axis assembly easy. See the individual table sections for more details. Other standard table series can have the top axis mounted to the bottom axis by adding new mounting holes in the bottom axis carriage. Contact *LINTECH* for more details.



X-Y System with Horizontal Angle Bracket



X-Y-Z System with Vertical Angle Bracket



X-Y System with Spread Rail X axis Base Plate

Environments

The life and performance of a positioning table is highly dependent upon its operating environment. Premature failure of a positioning table can occur if it is not designed to operate within the environment in which it is installed.

Standard *LINTECH* positioning tables within this catalog are designed to operate in most general industrial environments. The normal operating temperature can vary between 0° F to +185° F (-18° C to +85° C), while the general surrounding environment should be free of moisture, fine dust and corrosive chemicals. All aluminum components used in standard positioning tables are either black or clear anodized. All steel components (such as linear bearings & screws) require a level of lubrication to help prevent oxidation (rusting).

Aluminum cover plates are offered as an option on some belt & screw driven positioning tables. These covers protect the linear bearings and drive mechanism from falling objects, while they also help protect operating personnel from some moving table components by minimizing "pinch points". Hypalon polyester, neoprene coated polyurethane, and nylon/PVC waycovers (bellows) are also offered as an option on some belt & screw driven positioning tables. These covers significantly increase the protection of the linear bearings and drive mechanism from liquid mists and airborne particulates.

Operating a positioning table in certain environments may require the use of special materials within the system. *LINTECH* can modify a standard table to operate in many different environments. Contact us with your special needs.

Clean Room Environments call for the removal of all (or most) particle generating components within a positioning table. Depending on the clean room requirement (class 100, 10 etc.), seals, plastics, wipers, and waycovers may need to be removed or replaced with special materials. The use of chrome plated or stainless steel hardware, along with special clean room lubricants will be required.

Corrosive Environments require chrome plated or stainless steel hardware to protect the linear bearing & drive mechanism, along with special lubricants that will operate within the application.

Dusty Environments will require waycovers to protect the linear bearing & drive mechanism from getting "gummed" up. For applications involving particulate contamination, a positive air pressure under the waycovers may be required.

High/Low Temperature Environments may require special linear bearings or drive mechanisms, along with special lubricants.

Vacuum Rated Environments down to 10⁻⁷ torr are possible by removing all rubber & plastic materials, along with all paint and grease from table surfaces. Vacuum compatible lubricants, special insulated cabling, and special plated materials may be required.

Wash Down Environments require chrome plated or stainless steel hardware to protect the linear bearing & drive mechanism, along with special lubricants that will operate within the application.

Welding Environments may require the use of special telescoping steel (or fire proof) waycovers to protect the linear bearing and drive mechanism from hot debris.

Testing

All standard *LINTECH* positioning tables in this catalog use precision components that are manufactured to tight tolerances. Special tools, equipment, assembly surfaces, and certain procedures are adhered to during the manufacturing process. Each individual table manufactured will meet or exceed listed specifications based on the following requirements.

First, the proper table has been selected using the recommended safety factors for the applied load. Second, the positioning table is properly mounted to the user structure based on flatness & deflection guidelines. Third, the positioning table is operated by a motion controller that will not exceed listed maximum speeds and/or prevents a system from crashing.

Testing by *LINTECH* on a given positioning table can be performed to yield information for:

- * repeatability
- * position accuracy
- * straightness
- * flatness
- * other requested user data

All testing is performed by *LINTECH* unloaded and in a controlled environment. Test results are provided via a written report. The cost of testing a positioning table depends on the data required, table series, and travel length. Contact *LINTECH* for costs associated with the testing of a given positioning table. Also, the testing of a positioning table could add from 1 to 2 weeks to the normal delivery time.

It should be noted that *LINTECH* believes testing & verifying the true performance of any positioning table, for a specific application, should be done within the confines of the user's system and not in a controlled environment. Having *LINTECH* test a system that is not mounted to the applications final machine structure, without the exact applied load & motion controller, and without the final operating environment, will yield test results that could be irrelevant. Therefore, for a majority of positioning system applications *LINTECH* recommends testing to be done at the user's facility.

Custom Systems

LINTECH has been manufacturing custom positioning systems for use in a wide variety of applications for over 30 years. See pages A-4 to A-7. Some of these custom systems have been simple modifications of carriage assemblies, special base mounting hole patterns, nonstandard travel lengths, specific motor mount brackets, or different accessories such as couplings, encoders, or waycovers.

Other more involved custom systems have been:

- * 30 x 30 x 30 foot X-Y-Z inspection stations
- * 60 foot part placement machines
- * 5,000 pound load capacity assembly stations.
- * vacuum or wash down rated
- * 9 axis special assembly machines

All of these custom systems were successful by following a simple approach.

Review, fill out, and provide all the information on the application guide on page A-45. Providing us with all, or as much detail up front, can lead to the successful completion of a custom system. Then submit this information to *LINTECH* and we will review the data, to see if it is within our capabilities to manufacture.

Some of the more important information to provide us follows:

Budget will become extremely important in our evaluation process with you. With our many years of experience building custom systems we will be able to determine if the required performance you are seeking is possible within your budget.

Accuracy or Repeatability will make a big difference in the cost of a custom system. The accuracy of 0.0002 inches over 48 inches of travel will cost a whole lot more than a repeatability of 0.0002 inches over the same 48 inches of travel.

Load Weight will have an impact on the linear bearing, drive assembly, and structure that we would design for the custom system. Providing a realistic estimated of load weight (along with any other potential external forces), without too much of a safety factor will help select the proper custom positioning components. We will use the proper safety factors based on your application details.

Required System Life will also affect the selection of the proper components for the system.

Systems Speeds may affect the cost of a custom system if larger, more expensive components are required to meet the application needs. Providing us with a realistic target speed helps create a successful custom system.

Application Sketch (or diagram) can help minimize the time for us to respond to your request.

Other Details such as waycovers, motor mounts, or carriage size may not seem like key items to mention. However, providing us with as much information on the application requirements will lead to the successful completion of a custom system.

Design Considerations

Application Guide

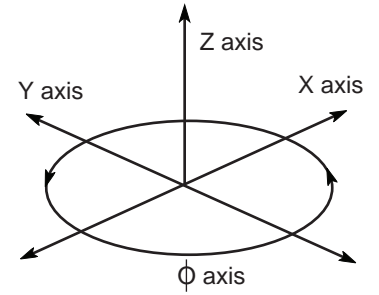
Name _____ Date _____

Company _____

Address _____

City _____ State _____ Zip _____

Phone () _____ Fax () _____



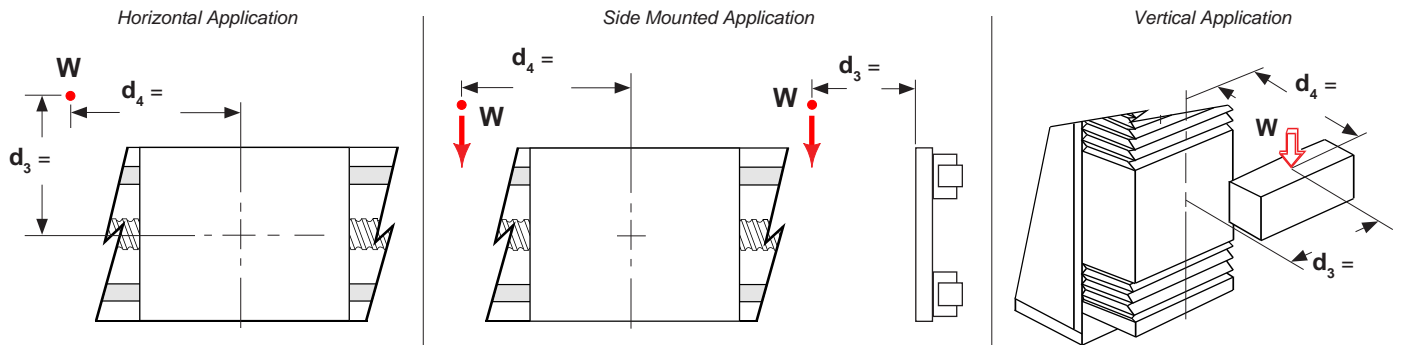
Positioning System Specifications Budget (per system) _____

Axis	X	Y	Z	Φ	Axis	X	Y	Z	Φ
Carriage Size length x width (in or mm)					Maximum Accel (in/sec ² or m/sec ²)				
Travel Length (in or mm)					Duty Cycle (%)				
Load Weight (lbs or kg)					Table Life (millions of inches or Km)				
Repeatability (in or mm)					Motor Frame Size (NEMA 23, 34, 42, other)				
Accuracy (Overall - in or mm)					Limit Switch Type (mech, reed, hall, prox)				
Maximum Speed (in/sec or mm/sec)					Waycovers (Yes or No)				
Most Difficult Move Profile	Distance (in or mm)				Encoder (linear, rotary, & resolution)				
	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)

Moment Loads

Load Center of Gravity Distance from Carriage Center (in or mm)



Load Weight (W) _____ (lbs or kg)

Application Details (please describe and attach separate sketch if required)

Torque Requirements

The torque required to move a *LINTECH* positioning table for a specific application requires the calculation of several simple equations. These equations require you to evaluate carriage speeds, acceleration rates, and load weights. Careful torque calculations allow the proper selection of an electronic motor/drive system.

The maximum torque demand from any motor is usually during the acceleration portion of a move profile and consists of several parts - Acceleration Torque, Friction Torque, Breakaway Torque, and for vertical applications the Torque to overcome Gravity.

The torque required from a motor varies as the move profile changes from acceleration to constant velocity to deceleration. Constant velocity torque and deceleration torque become important when sizing for a servo motor system. Torque to overcome gravity becomes extremely important in vertical applications. The upward move places the highest torque demand on the motor, while the downward move sometimes requires the motor/drive system to act as a

Step Motors

When sizing for a step motor system, calculate the maximum torque demand for the application. This will usually be the total torque required during the acceleration portion of a move profile. Select an electronic motor/drive system which will deliver more torque than is absolutely required. This torque margin accommodates mechanical wear, extra loads, lubricant hardening, and other unexpected factors. Consult the individual motor manufacturer for details on their required torque margin and inertia matching.

Servo Motors

When sizing for a servo motor system, two calculations must be performed - maximum (peak) torque and RMS (continuous) torque. The maximum torque demand for the application will usually occur during the acceleration portion of a move profile. The RMS torque calculation will require values for acceleration torque, constant velocity torque, deceleration torque, and the time between move profiles. All servo motor systems have a peak and continuous torque rating. Select an electronic motor/drive system which will deliver more peak torque than the calculated maximum torque value and more continuous torque than the RMS calculated value. This torque margin accommodates mechanical wear, extra loads, lubricant hardening, and other unexpected factors. Consult the individual motor manufacturer for details on their torque margin and inertia matching.

Torque Equations - (servo or step motor)

Horizontal Applications

$$T_{\text{Total-Accel}} = T_{\text{Acc}} + T_{\text{Breakaway}} + T_{\text{Friction}} + T_{\text{Gravity}}$$

$$T_{\text{Total-Constant}} = T_{\text{Breakaway}} + T_{\text{Friction}} + T_{\text{Gravity}}$$

$$T_{\text{Total-Decel}} = T_{\text{Acc}} - T_{\text{Breakaway}} - T_{\text{Friction}} - T_{\text{Gravity}}$$

Vertical Applications

Upward Move

$$T_{\text{Total-Accel}} = T_{\text{Acc}} + T_{\text{Breakaway}} + T_{\text{Friction}} + T_{\text{Gravity}}$$

$$T_{\text{Total-Constant}} = T_{\text{Breakaway}} + T_{\text{Friction}} + T_{\text{Gravity}}$$

$$T_{\text{Total-Decel}} = T_{\text{Acc}} - T_{\text{Breakaway}} - T_{\text{Friction}} - T_{\text{Gravity}}$$

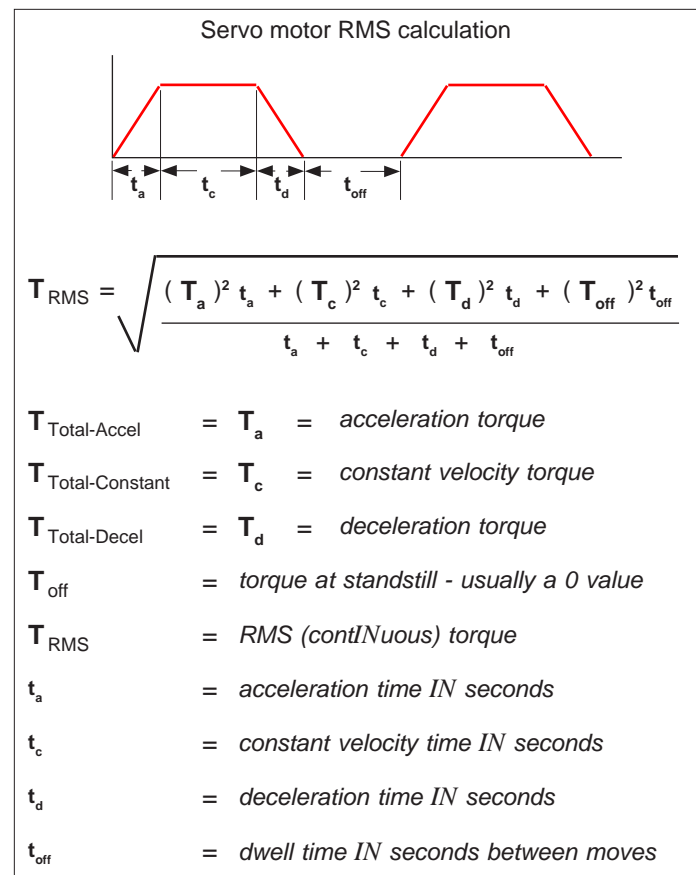
Vertical Applications

Downward Move

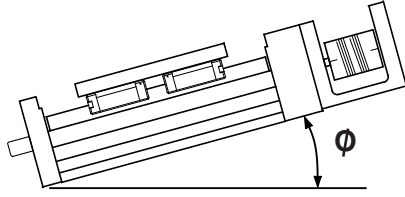
$$T_{\text{Total-Accel}} = T_{\text{Acc}} + T_{\text{Breakaway}} + T_{\text{Friction}} - T_{\text{Gravity}}$$

$$T_{\text{Total-Constant}} = T_{\text{Breakaway}} + T_{\text{Friction}} - T_{\text{Gravity}}$$

$$T_{\text{Total-Decel}} = T_{\text{Acc}} - T_{\text{Breakaway}} - T_{\text{Friction}} - T_{\text{Gravity}}$$



Torque Equations - Screw Driven (Linear Motion)



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

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

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

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

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

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

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

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

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

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

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.

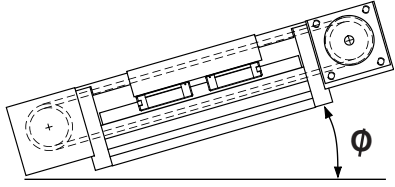
Thrust Force Equation

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

Terms

C_T	= potential 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_{Screw}	= screw inertia (oz-in^2)
J_{Motor}	= motor inertia (oz-in^2)
L	= screw length (in)
ϕ	= angle of load from horizontal (degrees)
ρ	= density of steel screw (4.48 oz/in^3)
R	= radius of 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_{Motor}	= motor output torque at calculated speed (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 carriage or weight of mounting hardware (lbs)
π	= 3.1416

Torque Equations - Belt Driven (Linear Motion)



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

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

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

$$J_{Pulley} = \frac{(W_{Pulley}) r^2}{2 g^2} \quad 2 \text{ (for 2 pulleys)} \quad (\text{oz-in}^2)$$

$$J_{Belt} = \frac{(W_{Belt}) r^2}{g^2} \quad (\text{oz-in}^2)$$

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

$$\omega = \frac{V_M}{r} \quad (\text{rad/sec})$$

$$T_{Breakaway} = \frac{\text{See values in individual belt technical sections}}{g e} \quad (\text{oz-in})$$

$$T_{Friction} = \frac{(W_{Load} + W_{Other}) r \mu \text{Cos } \phi}{g e} \frac{(16 \text{ oz})}{\text{lb}} \quad (\text{oz-in})$$

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

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/sec² or 32.2 ft/sec²) and converts inertia from units of oz-in² to oz-in-sec².

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.

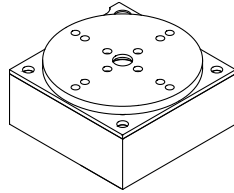
Thrust Force Equation

$$C_T = \frac{(T_{Motor} - T_{Total}) g e}{r} \frac{\text{lb}}{(16 \text{ oz})} \quad (\text{lbs})$$

Terms

C_T	= potential thrust force (lbs)
e	= gearhead efficiency (90% = .9)
g	= gearhead ratio (5:1 = 5)
J_{Belt}	= belt inertia (oz-in ²)
J_{Load}	= load inertia (oz-in ²)
J_{Motor}	= motor inertia (oz-in ²)
J_{Pulley}	= pulley inertia (oz-in ²)
ϕ	= angle of load from horizontal (degrees)
r	= radius of drive pulley (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_{Motor}	= motor output torque at calculated speed (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_{Belt}	= weight of belt (oz)
W_{Load}	= weight of load (lbs)
W_{Other}	= weight of carriage or weight of mounting hardware (lbs)
W_{Pulley}	= weight of pulley (oz)

Torque Equations - Worm Gear Driven (Rotary Motion)



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

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

$$J_{\text{Load}} = \frac{(W_{\text{Load}} + W_{\text{Table Top}}) R^2}{2 N^2} \left(\frac{16 \text{ oz}}{\text{lb}} \right) \quad (\text{oz-in}^2)$$

$$J_{\text{Worm}} = \text{See values in individual rotary table technical sections} \quad (\text{oz-in}^2)$$

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

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

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

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 $T_{\text{Breakaway}}$ 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/sec² or 32.2 ft/sec²) and converts inertia from units of oz-in² to oz-in-sec².

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.

4) The frictional torque value is so small, it can be ignored for rotary table torque equations.

Terms

e	= worm gear assembly efficiency (90% = .9)
J_{Load}	= load inertia (oz-in ²)
J_{Motor}	= motor inertia (oz-in ²)
J_{Worm}	= worm gear assembly inertia (oz-in ²)
N	= worm gear reduction (45:1 = 45)
R	= radius of table top (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_{Total}	= required torque to move the load (oz-in)
V_M	= max table top velocity (revs/sec)
ω	= angular velocity (rad/sec)
W_{Load}	= weight of load (lbs)
W_{Table Top}	= weight of table top or weight of mounting hardware (lbs)
π	= 3.1416

Abbe Error: The linear positioning error caused by the angular errors of the linear bearings, and the offset between the precision determining element (screw or feedback device), and the actual point of interest.

Acceleration: The positive rate of change in velocity from a lower to a higher speed as a function of time. ($1g = 386 \text{ in/sec}^2 = 9.81 \text{ m/sec}^2$).

Accuracy: Maximum deviation between desired & actual position when a positioning system performs a move. See page A-30.

Acme Screw: Device that converts rotary to linear motion by using a solid material that slides on a screw shaft thread surface (similar to a nut & bolt). High friction, low efficiency, smooth motion drive mechanism. See page A-13.

AGMA Class 10: American Gear Manufacturers Association classification of the gears used in a worm gear assembly.

Angular Contact Bearings: Rotary bearing used to support the table top in a rotary positioning table and also used as a screw end support.

Anodize: Black or clear protective coating created on aluminum.

Axial Load: The load generated in the direction of travel that a drive mechanism experiences. See page A-23.

Back-driving: The ability of a drive mechanism to move when an external force is exerted upon it.

Backlash: The movement of the drive mechanism before carriage (or table top) movement. Caused by the clearance of the drive mechanism components.

Ball & Rod Bearing: Load carrying element which utilizes non-recirculating steel balls rolling between four steel rods (two mounted to the carriage and two mounted to the base). See page A-10.

Ball Screw: Device that converts rotary to linear motion by using recirculating balls in a nut that roll on a screw shaft thread surface. Low friction and high efficiency provide for a high speed, long life and high duty cycle assembly. See drive page A-13.

Base: Precision machined aluminum (or steel) structure used to support the linear bearing system and the drive mechanism of a positioning table.

Bearing Dynamic Capacity: The maximum load (lbs or kg) applied to a bearing which will yield the rated travel life of 2 million inches (50 km). See page A-17.

Bearing Static Capacity: The maximum load (lbs or kg) applied to a bearing in a non-moving state. See page A-17.

Belt Tensile Force: The maximum applied force, from either an attached motor's acceleration rate, or through the belt tension which will permanently deform the belt.

Bidirectional Repeatability: How accurate (from either direction) a positioning system can return to a known previously traveled location. See page A-33.

Breakaway Torque: The torque required to start table motion. Consists of linear bearing & drive mechanism preload force, seal drag and the component of static friction (stiction).

Carriage: Aluminum or steel precision machined plate that carries the user mounted load. The linear bearings and screw nut adapter bracket (or belt ends) are mounted to this plate.

Closed Loop: Broadly applied term relating to any system where the output of a device is measured and compared to the input. The output is then adjusted to reach the desired condition.

Coefficient of Friction: The ratio of the force required to move an attached load versus the load itself. For linear bearing systems with rolling balls typically between (0.0001 to 0.01).

Compression Loading: The load acting on the drive screw assembly which would tend to compress or buckle the screw. Can occur in vertical and long length horizontal screw applications.

Concentricity: The radial runout (deviation) between a perfect circle and the path the table top takes throughout one full rotation of the table top. See page A-32

Cover Plate: Cover which protects the linear rails & drive mechanism of a linear positioning table.

Critical Speed: Maximum rotational speed of an acme or ball screw shaft prior to creating excessive resonant vibrations. Determined by screw length, diameter and end support configuration.

Cross Roller Bearing: Load carrying element which utilizes non-recirculating cylindrical rollers rotating between two "V" ways (one mounted to the carriage and one mounted to the base). See page A-10.

Deceleration: The negative rate of change in velocity from a higher to a lower speed as a function of time. ($1g = 386 \text{ in/sec}^2 = 9.81 \text{ m/sec}^2$).

Deflection: Amount of displacement (inches or mm) that a positioning table experiences caused by an applied load. See page A-27.

Diameter: Outer dimension of a drive screw shaft, pulley for a belt drive mechanism, or table top for a rotary table.

Drive Mechanism: Assembly consisting of components used to physically move a positioning system carriage or table top. See page A-13.

Drunkness: Relates to the drive screw's per revolution geometric variations. Derived from manufacturing tolerances of the screw thread with deviations that are concentric and perpendicular to the screw.

Duty Cycle: Percentage of time between a positioning systems dynamic (moving) state and the total move cycle time (move time + stationary time).

Dynamic Braking: Technique within a motor control unit that stops a motor.

Dynamic Horizontal Load Capacity: The maximum load (lbs or kg) centered on a positioning table's carriage (or table top), which will yield the rated travel life with the table mounted in a horizontal plane.

Dynamic Moment Load Capacity: The maximum load (ft-lbs or N-m) acting upon a carriage or table top which will yield the rated travel life.

Dynamic Pitch, Roll & Yaw Moment Load Capacity: The maximum pitch, roll or yaw load (ft-lbs or N-m) acting upon a linear positioning table carriage which will yield the rated travel life.

Efficiency: Percentage of input torque which is transmitted through the mechanical drive assembly (screw, worm gear, or gearhead).

Encoder: Rotary or linear electrical pulse generating device which is used to provide feedback to a motion controller or digital display.

End Plates: That part of a linear positioning table which supports either screw end support bearings or belt pulleys.

EOT (End of Travel Switch): Electrical switch which signals to a motion controller that the carriage of a linear positioning table has reached the end of its travel. Used to prevent carriage from contacting end plates. See page A-38.

Feedback: Signal that is transferred from the output back to the input for use in a closed loop system.

Fixed-Simple: Method of supporting screw shaft ends within a linear positioning table. Removes end play within a screw assembly.

Flatness: Maximum vertical deviation of carriage travel from a straight line. See page A-30.

Friction: The resistance to motion caused by surfaces rubbing together within bearings and drive mechanisms.

Gearhead: Gear reducing device which mounts to the input of a belt (or screw) driven positioning table. This device increases the output torque from the motor by the ratio amount, while reducing the reflected load inertia to the motor by the inverse of the ratio squared (e.g. 5:1 ratio increases torque five times and reduces reflected inertia by 25 times).

Hall Effect Switch: Non-contact sensor mounted to a table base which detects a magnet located on the carriage (or table top). Used for EOT and/or home sensing.

Hand Crank: Device that is mounted to a screw shaft extension (or drive shaft) of a linear positioning system which allows for manual table positioning.

Hard Stop: The physical end of travel (end plates) for a linear positioning table. EOT switches should be used to prevent hard stop collisions.

Home Switch: Electrical switch which signals to a motion controller that the carriage (or table top) has reached a known reference location on a positioning table. See page A-38.

Impact Load: Forceful load striking (colliding) a positioning system carriage, structure or table top.

Inertia: The measure of an object's resistance to a change in velocity. The larger an object's inertia (mass & shape), the greater the force or torque required to move it.

Inertia Match: Ratio of the drive mechanism, load, and coupling inertias that are reflected back to the output shaft of a motor.

Lead: The linear distance traveled by a drive mechanism (screw or belt) during one complete revolution of the drive mechanism.

Leadscrew: Another name for an acme screw. See acme screw. See page A-13.

Load: Dynamic & static forces (due to weight or motion) that positioning table components are subjected to.

Lubrication: Process of applying grease or oil between two solid surfaces with the intent of reducing friction, heat, and wear by creating a thin film between the surfaces.

Maximum Acceleration: The maximum acceleration a positioning system can experience before causing damage or failure of table components. See page A-29.

Maximum Speed: The maximum speed a positioning system can experience before causing damage or failure of table components. See page A-28.

Modulus of Elasticity: The ratio of unit stress to unit strain within the proportional limit of a material in shear.

Moment of Inertia: The measure of the strength of an object to resist deflecting ("I" value). See page A-27.

Motion Controller: The intelligent device that instructs (controls) the movement of a motor which is attached to a positioning table.

Motor Coupling: Device which connects the shaft of a motor to the drive mechanism shaft of a positioning table. See page A-37.

Motor Wrap: The process of locating a motor parallel to the positioning table via a belt & pulley assembly. Used for screw drive positioning tables.

NEMA: National Electrical Manufacturers Association which sets standards for motor dimensions.

NEMA Motor Mount: Bracket which has a predefined dimension and bolt hole locations for mounting of either a NEMA 23, 34 or 42 size motor.

Non-Preloaded Nut: A nut which has axial clearance (backlash) between the nut and screw threads.

Non-Recirculating Bearings: Bearings that have balls/rollers which roll in an assembly. The balls/rollers do not recirculate in & out of load points.

Normally Closed (NC) Switch: Sensor output signal is normally always active until tripped.

Normally Open (NO) Switch: Sensor output signal is normally always inactive until tripped.

NPN Switch: Current sinking electrical output which supplies a path to ground

Open Loop: Broadly applied term relating to any system where the output of a device is not sensed, therefore no corrective action can be taken for unwanted errors.

Orthogonality: The degree of perpendicularity (squareness) between two axes.

Pitch: The distance from the center of one thread to the center of the next thread. The relationship between pitch and lead differ depending on the number of screw thread "starts". Pitch is often referred to as the inverse of lead, however this is not true for screws with multi-start nuts.

PNP Switch: Current sourcing electrical output which supplies a path to a positive voltage.

Position Accuracy: Maximum deviation between desired & actual position when a positioning system performs a move. See page A-30.

Power-Off Brake: Device which is used to hold a linear positioning table drive mechanism securely in place. See page A-40.

Preloaded Nut: A nut assembly in which there is no axial clearance (backlash) between the nut and screw threads.

Radial Bearings: Rotary bearing used to support the table top in a rotary positioning table and also used as a screw end support.

Recirculating Bearings: Bearings that have balls/rollers which recirculate in & out of load points within its assembly.

Repeatability: How accurate a positioning system can (over successive attempts) return to a known previously traveled location. See page A-33.

Resolution: Smallest detectable incremental of measurement for a system. Influenced by drive mechanism (mechanical resolution), motor resolution (electrical resolution), and encoder feedback (closed-loop resolution). See page A-15.

Runout: Maximum vertical deviation above or below a horizontal plane that is perpendicular to the axis of motion the table top rotates in. See page A-32.

Safety Factor: Number used to help calculate dynamic & static forces acting upon a positioning system based on application parameters

Squareness: The degree of perpendicularity (Orthogonality) between two axes.

Stackup Errors: In multi-axis positioning systems, the angular errors transmitted from the bottom axes to the top axes.

Static Horizontal Load Capacity: The maximum load (lbs or kg) centered on a positioning table's carriage (or table top), with the table in a non-moving (rest) state.

Static Moment Load Capacity: The maximum load (ft-lbs or N-m) acting upon a carriage, or table top with the table in a non-moving (rest) state.

Static Pitch, Roll & Yaw Moment: The maximum pitch, roll or yaw load (ft-lbs or N-m) acting upon a linear positioning table carriage with the table in a non-moving (rest) state.

Stiction: The static friction usually present in linear bearing & drive mechanism assemblies that can cause a positioning system to stick (cog) at low speeds.

Tension Loading: The load acting on the drive screw assembly which would tend to stretch the screw. For vertical applications, it is better to configure a screw driven positioning table to be in tension and not compression. This is accomplished by mounting the motor mount end up, above the table.

Thrust Force: The axial load (force) generated in the direction of travel by a drive mechanism and attached motor of a positioning system. See page A-23.

Torque: The rotary equivalent to force. Equal to the product of the force perpendicular to the radius of motion and distance from center of rotation to the point where the force is applied.

Torque, Acceleration: The torque required to change the speed of a positioning table.

Torque, Breakaway: See Breakaway Torque on page A-50.

Torque, Continuous: The torque required to move a positioning table at a constant travel rate.

Torque, Gravity: The torque required to move a positioning table to overcome gravity. Occurs in applications where the table is not horizontal.

Travel Length: Usable travel of the carriage for a given positioning table series within this catalog. Ratings are from hard stop to hard stop. Travel reductions can occur when selecting various screw options.

Unidirectional Repeatability: How accurate a positioning system can return to a known previously traveled location by approaching from the same direction. See page A-33.

Wind-up: Lost motion (angular deflection) due to compliances within a drive assembly or motor coupling as a torque is applied to a positioning table.

Wobble: The angular variation (axis runout) from the true centerline of rotation throughout one full rotation of a rotary positioning table top. See page A-32.

Worm Gear: Drive assembly which uses a pair of matched gears. The cylindrical worm (similar in looks to an acme screw) physically meshes with the teeth on the worm wheel to create rotary motion.

