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.

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.
**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.

**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.
**Design Considerations**

**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.

**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.