INDUSTRY FOCUS

Laboratory Automation

Positioning and Guidance Solutions

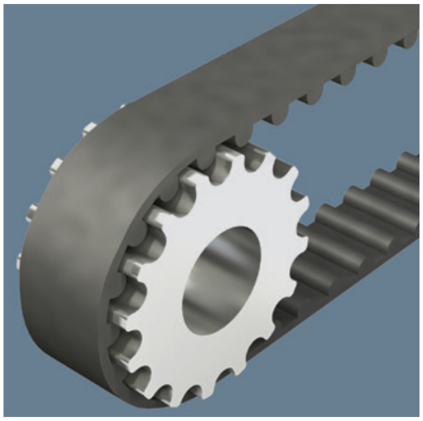
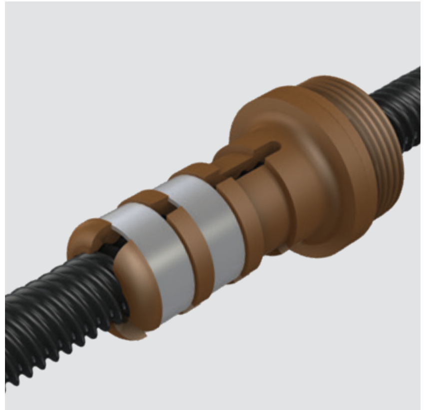
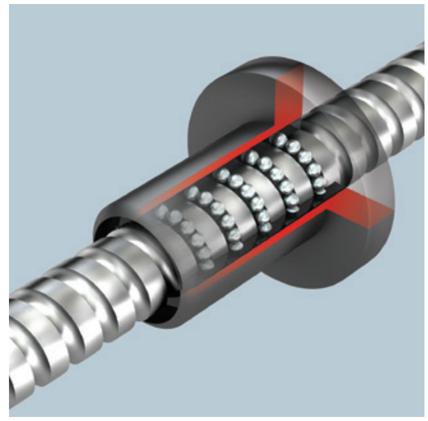
Linear drive systems enable a range of laboratory automation applications.

Increased productivity, higher accuracy, and better reproducibility of experimental results are driving increased use of linear motion solutions for laboratory automation.

Lab automation not only makes scientific experiments and processes faster, more accurate, and more efficient, but it also allows researchers to run experiments on a larger scale while reducing the likelihood of human error. By managing larger volumes of samples and data, automation provides the ability to perform experiments 24/7 without the need for human intervention, freeing up time for researchers to focus on other tasks.

Laboratory automation is becoming increasingly essential in various fields, including drug discovery, clinical diagnostics, and biotechnology. Linear motion is essential for a wide range of laboratory automation applications and is key to successfully developing, progressing, and deploying lab automation technologies for the future. However, laboratory automation applications present unique linear motion challenges: Motion must be precise, consistent, and repeatable. Systems must be able to handle dynamic loads in tight spaces. They must operate in sterile environments, with minimal wear debris and minimal noise, vibrations, and mechanical disruptions.

Lab automation system success greatly depends on the proper selection of suitable linear drive system components. Engineers developing motion systems for new and existing lab automation applications confront two main challenges. First, the systems must meet a variety of requirements in the areas of reliability, accuracy, repeatability, size constraints, noise limitations, and more. Secondly, with numerous linear motion devices available, choosing the right one can be complex.

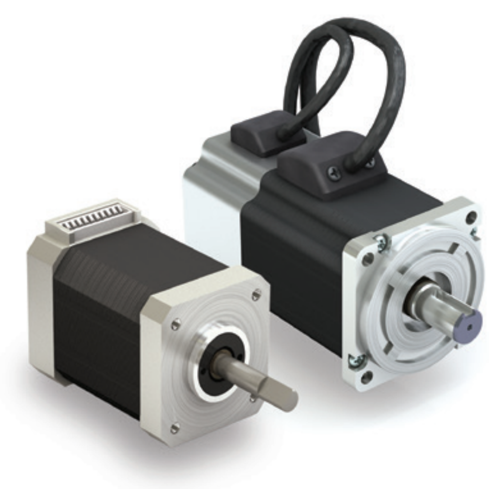




Linear Drive Technologies

Lead screws, ball screws, and belt drives remain the primary drive technologies for linear motion systems. Engineers prefer belt-driven modules for applications that demand higher-speed transport and longer travel distances. In contrast, they tend to specify screw drives for applications that require a high degree of accuracy and repeatability at the endpoint. Screws also provide more precise alignment, whereas belt drives are generally easier to integrate due to their tension adjustment capability.

Lead Screws Versus Ball Screws

Linear electric actuators with either lead screw or ball screw drives are crucial in many laboratory automation applications. Lead screws transfer loads using a sliding motion on flat surfaces, while ball screws use matching helical grooves on both the screw and the nut. A ball screw is highly efficient due to a system of balls that create rolling contact between the screw axis and the nut, creating a drive torque of one-third or less compared to a regular sliding screw. This makes the ball screw an ideal option for applications where size and energy efficiency are important considerations.



Stepper Motors Versus Servo Motors

Engineers frequently specify stepper or servo motors when they need precise rotary motion for driving a lead screw or ball screw actuator. Stepper motors move in small increments within a closed-loop system using a consistent pulse, without the need for a feedback encoder. In contrast, servo motors employ an encoder to adjust pulses for position control. While servo motors offer better performance, stepper motors can be a cost-effective alternative for applications that do not require high speeds and other scenarios that demand accurate and reliable positioning.

For low-speed, high-torque motion control applications, engineers often pair stepper motors with lead screws. Conversely, ball screws are best suited for high-speed and high-precision applications and thus require the advanced capabilities of a servo motor. In applications that demand both high speeds and high torque, a configuration that combines ball screws with servo motors is typically employed.

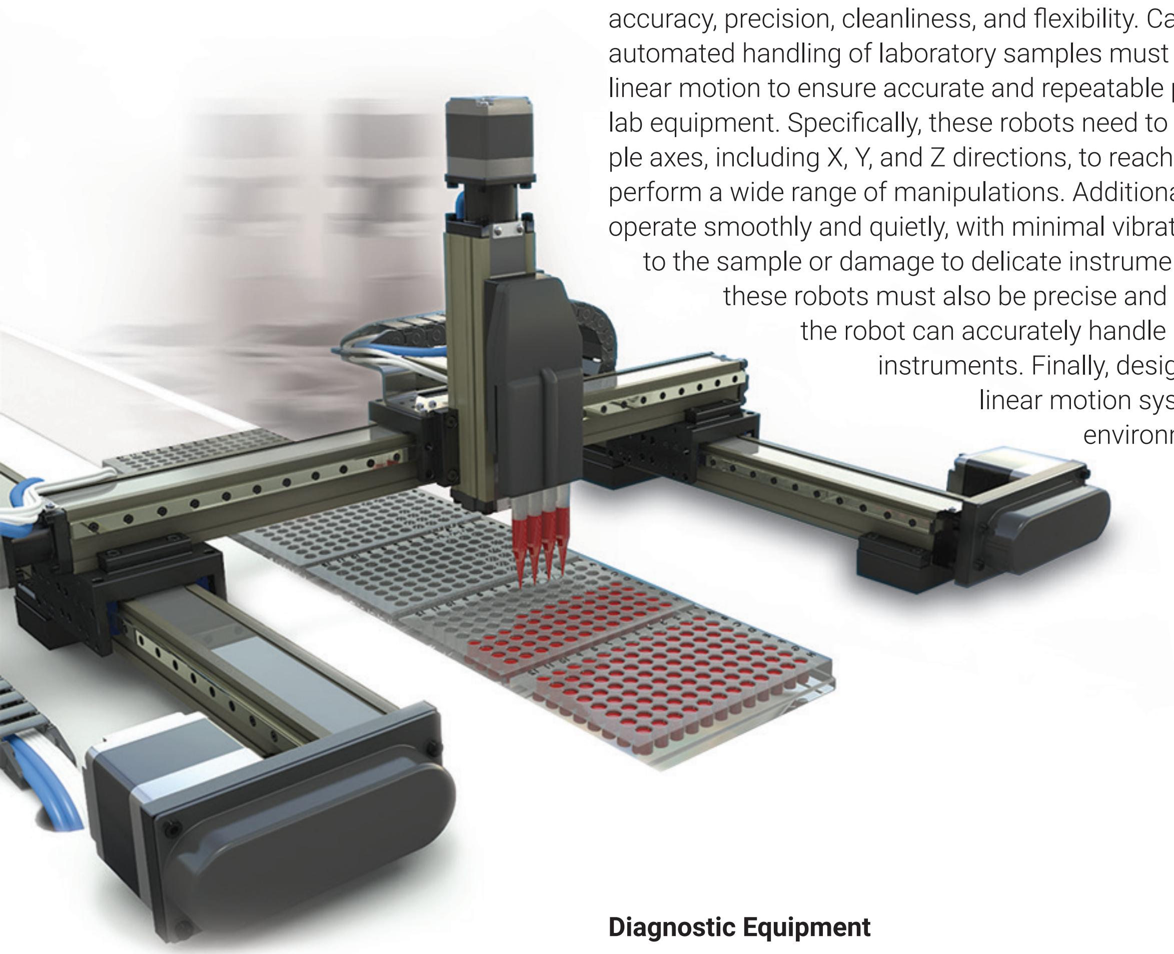
Lab Automation Applications That Benefit Most From Linear Motion

The wide range of linear actuators now available in the market expands the range of potential applications that can take advantage of linear motion. Linear motion is particularly useful in laboratory automation applications.

These applications include:

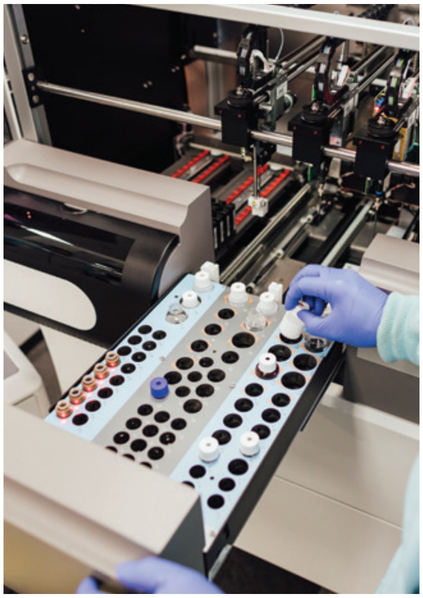
Cartesian Robots for Sample Handling

Cartesian robots in laboratory automation must provide a combination of accuracy, precision, cleanliness, and flexibility. Cartesian robots used for automated handling of laboratory samples must have precise and reliable linear motion to ensure accurate and repeatable positioning of samples and lab equipment. Specifically, these robots need to be able to move in multiple axes, including X, Y, and Z directions, to reach all areas of a sample and perform a wide range of manipulations. Additionally, they need to be able to operate smoothly and quietly, with minimal vibration, to avoid any disruption to the sample or damage to delicate instruments. The linear motion of these robots must also be precise and repeatable to ensure that the robot can accurately handle and position samples or instruments. Finally, designers must ensure that linear motion systems can operate in sterile environments and produce minimal wear debris to avoid contamination of samples.



Diagnostic Equipment

To ensure accurate and reliable test results, automated diagnostic equipment used in medical laboratories must meet unique linear motion requirements. The linear motion of this equipment must be precise and repeatable to move samples and reagents with high accuracy, and systems need to operate smoothly and quietly to avoid any disruption to the samples or equipment. Additionally, these systems must be able to handle a wide range of loads, including large and small sample volumes, and must be capable of operating at different speeds to accommodate various testing protocols. To avoid contamination of the samples, the designer must ensure that the linear motion system can operate in sterile environments with minimal wear debris. Additionally, the designer must integrate the linear motion system with advanced control systems that enable real-time feedback and control, ensuring efficient and consistent delivery of high-quality test results by the diagnostic equipment.



Precision Pick and Place

Clinical laboratories commonly use precision pick-and-place systems to handle and manipulate small, delicate samples automatically. These systems require highly precise linear motion capabilities. Some systems must be capable of moving samples with   accuracy to ensure accurate and consistent placement of samples in target locations, such as microscope slides or reaction vessels. The linear motion requirements of these pick-and-place systems include high accuracy and repeatability, with the ability to stop and start quickly and smoothly without causing any damage to the samples, all while providing smooth and precise movement with minimal vibration or noise. The systems must also be capable of handling dynamic loads, such as varying sample weights and sizes, and operating in sterile environments with minimal wear debris. Additionally, the linear motion system must be able to integrate with other components of a precision pick-and-place system, such as grippers and vision systems, and must be easily programmable for automated and customizable operations. Overall, linear motion plays a critical role in the precision and reliability of these systems, ensuring the accurate placement of laboratory samples and reducing the risk of errors or contamination.

Fluid Dispensing

Automated fluid dispensing systems used in clinical and research laboratories must have precise and repeatable linear motion to ensure the accurate delivery of fluids. These systems typically rely on linear actuators to control the movement of the dispensing nozzle or syringe pump. The linear motion system must be able to handle different fluid viscosities and volumes, with a high level of accuracy and repeatability. Additionally, the systems must operate in sterile environments, which require minimal wear debris and contamination from motion control components. The linear motion system must also be able to manage dynamic loads caused by fluid flow and changes in direction without introducing vibrations or other disturbances that could affect the accuracy of the dispensing. Additionally, the system must operate in sterile environments and minimize the risk of contamination. This requires the use of materials that are resistant to wear and tear, corrosion, and chemical damage.

Lab Instrumentation

Lab instrumentation in clinical and research settings often uses precise and repeatable linear motion to conduct various tasks, such as sample handling, mixing, and dispensing. Typical linear motion requirements for laboratory automation instrumentation include:

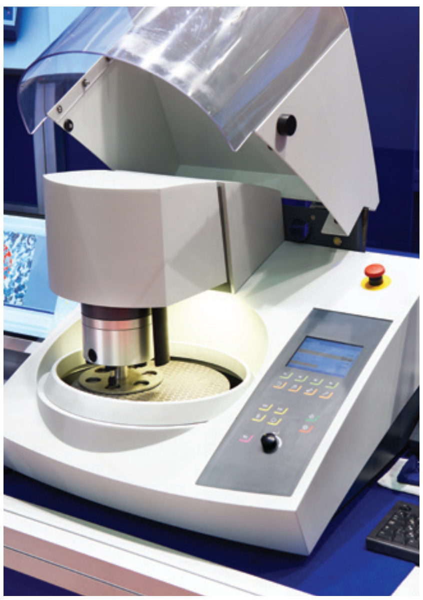
1. *Accurate positioning:* Instruments must be able to move and position samples precisely, within micron or even submicron levels, to ensure accurate and consistent results.

2. *High speed:* Some applications, such as high-throughput screening, require fast and efficient linear motion to manage large volumes of samples in a short time.

3. *Smooth and quiet operation:* Noise and vibration can affect the performance and accuracy of sensitive instruments, so smooth and quiet operation is a crucial requirement.

4. *Minimal maintenance:* Laboratory instruments often operate in sterile or clean environments. Such instruments must require minimal maintenance and generate minimal wear debris.
5. *Compatibility with diverse loads:* Automated laboratory instruments must be capable of managing a wide range of loads, from small samples to large containers, and must be adaptable to different types of samples, such as liquids, powders, and solids.
6. *Compact design:* To fit within the overall footprint of the instrument, the linear motion system must be compact and space-efficient, since laboratory instruments are often installed in limited space.

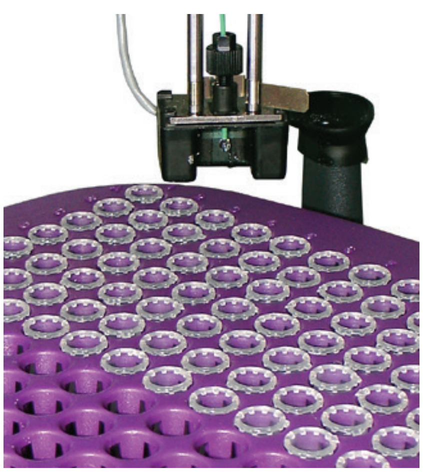
Overall, the linear motion requirements for automated laboratory instrumentation are diverse and highly specific. Often, customized solutions are required to meet the unique needs of each application.



Fluid Separation Devices

Automated fluid separation devices are essential in high-throughput clinical and research laboratories for separating and isolating specific components in fluids, such as blood or urine samples. These devices require precise linear motion control to accurately and consistently move and position components in the separation process, such as tubes, pipettes, and plates. The devices also use linear motion systems to accurately position and move fluids, such as blood or urine, through a series of chambers and filters to separate the components for analysis.

The linear motion requirements for these devices include precise positioning and alignment of the fluid-handling components, accurate and repeatable movement at high speeds to achieve high throughput, and the ability to manage varying loads and fluid volumes. Additionally, to ensure the integrity of the sample being processed, these devices must operate in sterile environments, free of contamination and with minimal wear debris. The linear actuators used in these devices must be able to provide precise control of the fluid-handling components with high positional accuracy and repeatability. They must also be able to manage high loads while being compact and able to fit into tight spaces. Finally, the actuators must operate quietly and without generating excessive vibration or heat that could interfere with the separation process.



Sample Rack Motion in Lab Analyzers

Sample rack motion systems used in lab analyzers require precise and repeatable linear motion. These systems are responsible for moving sample racks containing test tubes or other sample containers from one position to another within the analyzer, allowing the samples to be processed and analyzed. The systems must be able to manage a high volume of samples and move them quickly and accurately to minimize testing time. The systems must also be designed to handle the weight of the sample racks and any additional equipment while minimizing any vibration or noise that could impact the accuracy of the analysis. Additionally, systems must accommodate a variety of sample sizes and shapes and provide gentle handling to prevent damage while operating within a sterile or clean environment, with materials and lubricants that minimize wear and prevent contamination.

Partner With a Linear Motion Expert

As laboratory automation technologies continue to advance, linear motion technology must keep pace. By understanding the critical needs of your application, as described in this article, you can effectively communicate your requirements to a manufacturer and ensure that you receive the appropriate linear drive system for your application. However, to ensure that you have covered all the essential details, it is advisable to partner with an experienced manufacturer that can offer custom design support and provide you with the required product and performance. If you have any questions or would like to learn more about PBC Linear products and capabilities, please feel free to contact us. We are always ready to provide assistance with our team of experts.

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