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How can you ensure that you choose the right actuator? What variables does an industrial designer tackling a new application have to consider?When talking about linear motion solutions, the important thing is to consider the issue from the right viewpoint. Specifically, this means the application at hand. This is always first and foremost when deciding the type of linear actuator you need.When selecting a precision linear actuator, its crucial to clearly define your expectations for results and performance. This detailed analysis will help you tailor your precision linear actuator to your exact requirements.By thoroughly considering these factors, youll be better equipped to identify not only the type of precision linear actuator you need but also the specific specifications that will ensure optimal performance in your application.This careful selection process ensures that your chosen precision linear actuator will meet your unique needs with the highest level of accuracy and reliability.As such, it is worth starting by considering the dynamics, stroke length and precision requirements.Lets look at these in detail.High DynamicsIn many industrial design areas, the designers demands often involve speed. They typically include reducing cycle times as well. A good example of this is the packaging industry. After all, the more precise and speedier the packaging, the faster the packages are going out the door.It is no surprise, then, that high dynamics are commonly the starting point when defining a solution.Belt drives are often the ideal solution when it comes to high dynamics, considering that:they allow for accelerations up to 50 m/s2 and speeds up to 5 m/s on strokes as long as 10-12man X-Y-Z portal with belt-driven axes is capable of handling loads ranging from extremely small to approximately 200kgaccording to the type of lubrication, these systems can offer particularly long maintenance intervals, thus ensuring continuity of production.There are times when high dynamics are required on strokes longer than 10-12m. In these instances, actuators with rack and pinion drives tend to be an excellent solution. This is because these linear actuators allow for accelerations up to 10 m/s2 and speeds up to 3.5 m/s. And all of this on potentially infinite strokes.Rack and pinion actuator models implement the concept of a wheel and axle. Specifically, a rotating wheel moves a cable, chain, or belt to produce linear motion.The choice of a different type of actuator would not guarantee the same results. A screw system, for instance, which is undoubtedly much more precise, would certainly be too slow. With such an actuator, you would not be able to handle such long strokes.Though a screw actuator is an incredibly common tool, rotating the screw in order to drive it forward. However, it has limitations to speed depending on your scenario.A linear actuator is a mechanical device that creates motion in a straight line, as opposed to the circular motion typically produced by electric motors. Linear actuators convert different forms of energysuch as electrical, hydraulic, or pneumatic energyinto linear motion, allowing them to push, pull, or adjust objects or mechanisms. In simple terms, a linear actuator is used to create controlled movements in one direction, which makes it ideal for applications where precise positioning is necessary.Types of Linear ActuatorsThe three main types of linear actuators. They function differently but have the same end goal that is: converting energy into linear motion.Electric Linear Actuators: These use an electric motor to generate motion. Inside, a motor rotates a screw, which then moves a nut attached to a load in a straight line. This setup is efficient and precise, making electric actuators popular in automation and precise control systems.Hydraulic Linear Actuators: Powered by hydraulic fluid, these actuators rely on pressurized liquid to create movement. Hydraulic actuators are often used in heavy-duty applications, as they can generate high force, but they are more complex and require regular maintenance.Pneumatic Linear Actuators: These use compressed air to create movement. While less powerful than hydraulic actuators, pneumatic actuators are ideal for applications requiring quick movement and lower force levels.Can Linear Actuators Pull?Yes, many linear actuators are designed to perform both pushing and pulling functions. Electric and hydraulic linear actuators, in particular, are capable of handling loads in both directions, making them highly adaptable for various tasks. Whether lifting a heavy door or pulling a load along a rail, linear actuators can provide the necessary force to handle tasks that require bidirectional movement.Where Are Linear Actuators Used?The uses of linear actuators are extensive and span multiple industries. Some common areas where linear actuators are used include:Manufacturing and Automation: In factory automation, linear actuators assist in moving parts, controlling machinery, and positioning tools with precision.Robotics: Linear actuators enable robots to perform tasks requiring fine adjustments, like grasping or adjusting.Medical Equipment: Hospital beds, dental chairs, and imaging equipment rely on linear actuators for smooth, controlled motion to adjust positions.Automotive Applications: From opening and closing sunroofs to adjusting seats, linear actuators are embedded in various automotive features.Aerospace and Defense: Actuators are used for precise control in aircraft control surfaces, weapon systems, and radar positioning.How to Choose the Right Linear ActuatorChoosing the right linear actuator for your project is all about understanding the specific needs of your application.Heres a simplified guide to help you make the best choice:Define Your Load Requirements: Start by identifying how much force your actuator needs to exert. Different actuatorssuch as electric, hydraulic, and pneumaticoffer varying force capabilities. Electric actuators, for example, are great for lighter tasks requiring precision, while hydraulic actuators are better for heavy-duty applications.Consider Speed Needs: Some applications require fast, repetitive motion, while others need slower, more controlled movement. Pneumatic actuators generally excel at faster tasks, whereas electric actuators are better for applications where control and accuracy are key.Determine Stroke Length: The stroke length refers to how far the actuator needs to move to complete a task. Ensure that the actuators stroke length aligns with the motion range your project requires, so it doesnt overextend or fall short of reaching its target.Choose an Energy Source: Linear actuators can be powered by electric, hydraulic, or pneumatic energy. Electric actuators are popular for their precision and low maintenance, while hydraulic actuators are ideal for high-force applications and pneumatic actuators are best for fast, lightweight tasks.Consider Environment and Durability: Think about the setting where the actuator will be used. Is it a high-heat environment? Will it be exposed to moisture or dust? Electric actuators are more durable in clean, indoor environments, whereas hydraulic actuators can handle harsher, heavy-duty settings.Benefits of Linear ActuatorsLinear drive systems bring a wide range of benefits to automation and industrial processes, making them a valuable addition to various applications.Precision and Control: Linear actuators, especially electric ones, allow for exact control over positioning, speed, and force. This precision makes them ideal for applications like robotics, medical equipment, and manufacturing lines, where every movement counts.Reliability and Low Maintenance: Unlike hydraulic systems that require regular maintenance to check for leaks and fluid degradation, electric linear actuators operate without fluids. This design results in fewer moving parts, which means less wear and tear and lower maintenance costs over time.Energy Efficiency: Linear actuators, particularly electric models, consume power only when in motion. This feature makes them more energy-efficient compared to hydraulic or pneumatic systems that might require continuous pressure or airflow to operate.Quiet Operation: For applications where noise reduction is essentialsuch as in hospitals or office environmentselectric linear actuators offer a quieter alternative. Unlike hydraulic or pneumatic systems, they operate smoothly and with minimal sound.Environmental Friendliness: Linear actuators, especially electric ones, are eco-friendly as they eliminate the need for hydraulic fluids, which can leak and pose environmental risks. By choosing linear actuators, companies can reduce their environmental impact and support cleaner operations.Versatility Across Applications: Linear actuators are versatile and adaptable to a range of tasks, from simple lifting and lowering to complex, precise positioning. Theyre found in industries as diverse as automotive, electronics, healthcare, and renewable energy, proving their effectiveness in both heavy-duty and delicate applications.ConclusionBy converting energy into linear motion, these actuators enable smooth, precise movement, making them invaluable in manufacturing, medical equipment, and automation. With the ability to push, pull, lift, and adjust with accuracy, linear actuators have become a foundational component in modern machinery and technology. Whether in robotics, automotive systems, or industrial automation, linear actuators provide the controlled motion essential for countless applications.Choosing the right linear actuator is key to optimizing your operations, and Fangtooth is here to help. Connect with us for tailored solutions that meet your unique needs, ensuring you get the perfect fit for precision, durability, and efficiency.Table Of ContentsRequest A Quote Electric linear actuators are versatile and powerful devices that can be used to create precise linear motion in a variety of applications. From manufacturing automation to product design, they continue to be an essential tool for design engineers seeking innovative solutions.With so many options and technical details to consider, it can be challenging to know which technology is the right fit for your unique needs. Thats why weve put together this guide to answer the most frequently asked questions about electric linear actuators from how they work to their most common applications.How does a linear actuator work?A linear actuator is a device that converts rotational motion into linear motion in order to move objects in a straight line. They typically consist of an electric motor and a lead, ball, or roller screw which translates the rotary motion of the motor into linear motion.When the motor is activated, it rotates the screw, which moves the nut or guide mechanism along its length, subsequently moving any attached loads.Linear actuators can be powered by AC or DC electric motors and controlled by a variety of means like switches, potentiometers or programmable controllers. Some linear actuators are also equipped with sensors that provide performance feedback on position, velocity and force.What are the different types of linear actuators?There are four main varieties of linear actuator: electric, hydraulic and pneumatic. Each variety has its own unique characteristics:Electric linear actuators. Electric linear actuators are precise, efficient, and controllable with a wide range of force output and speed options. They are also relatively quiet and low-maintenance, making them ideal for the widest variety of applications. The varieties of electric linear actuators are vast and include rodless electro-mechanical actuators, electric rod actuators, roller screw actuators and beyond.Hydraulic linear actuators. Hydraulic linear actuators use pressurized fluid to create linear motion. A piston or plunger is driven forward or backward by the fluid, which in turn creates movement. Hydraulic linear actuators are powerful and capable of generating high force output, making them ideal for heavy-duty applications. However, they can be noisy and require more maintenance than other types of actuators.Pneumatic linear actuators. Pneumatic linear actuators use compressed air to generate linear motion. The air is typically delivered to a piston or diaphragm, which then moves back and forth. Pneumatic linear actuators are relatively inexpensive and offer quick, responsive motion in both rodless and rod-style options.Does a linear actuator need a motor?Yes, an electric linear actuator requires some form of motor in order to generate linear motion. The type of motor will depend on the type of actuator: the force and speed requirements.How do you control an electric linear actuator?Electric linear actuators can be controlled in a number of ways depending on the specific requirement of their proposed application. Common interfaces include end-to-end travel, switches and programmable controllers.End-to-End Travel. Actuator has a hard stop at the beginning and end of travel with no other positioning. They are either fully extended or retracted.Switches. Switches are the simplest way of controlling electric linear actuators. They can be as simple as on/off or more complex with additional positions that give more specialized movement control.Programmable controllers. Programmable controllers are often used to control actuators in industrial applications where unique positions or movement patterns are required.Its recommended to consult the manufacturers specifications or consult with an expert to determine the most appropriate method of control for your unique electric linear actuator application.Can electric linear actuators be customized to meet specific requirements?Yes. If you have a unique application need, the right partner will be able to design and engineer a custom linear actuator to meet your needs. Tolomatic has a model shop staffed by skilled engineers and technicians that design, model and test prototypes.Curious about the process? Heres how it works:Requirements Consultation: First youll collaborate with our design engineers for preliminary evaluation and concept analysis.Preliminary Design: Next we combine your needs with our expertise to develop an initial product design.Rapid Prototype: Youll receive a prototype product for initial evaluation of form, fit, and function.Design Verification and Acceptance: Testing occurs to verify performance to your specifications.Production: Once we have final approval, your customized product will be produced and delivered.Have more questions about electric linear actuators?If youd like to have additional information about electric linear actuator solutions explained, get in touch with our team. Were happy to help. This article needs additional citations for verification. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed.Find sources:"Linear actuator"news newspapers books scholar JSTOR (July 2008) (Learn how and when to remove this message)A linear actuator is an actuator that creates motion in a straight line, in contrast to the circular motion of a conventional electric motor. Linear actuators are used in machine tools and industrial machinery, in computer peripherals such as disk drives and printers, in valves and dampers, and in many other places where linear motion is required. Hydraulic or pneumatic cylinders inherently produce linear motion. Many other mechanisms are used to generate linear motion from a rotating motor. Conceptual design of a basic traveling-nut linear actuator. In this example the lead screw (gray) rotates while the lead nut (yellow) and tube (red) do not.DVD drive with leadscrew and stepper motor.Floppy disc drive with leadscrew and stepper motor.A mechanical linear actuator with digital readout (a type of micrometer).Roller screw actuation with traveling screw (rotating nut).Mechanical linear actuators typically operate by conversion of rotary motion into linear motion. Conversion is commonly made via a few simple types of mechanism:Screw: leadscrew, screw jack, ball screw and roller screw actuators all operate on the principle of the simple machine known as the screw. By rotating the actuator's nut, the screw shaft moves in a line.Wheel and axle: Hoist, winch, rack and pinion, chain drive, belt drive, rigid chain and rigid belt actuators operate on the principle of the wheel and axle. A rotating wheel moves a cable, rack, chain or belt to produce linear motion.[1]Cam: Cam actuators function on a principle similar to that of the wedge, but provide relatively limited travel. As a wheel-like cam rotates, its eccentric shape provides thrust at the base of a shaft.Some mechanical linear actuators only pull, such as hoists, chain drive and belt drives. Others only push (such as a cam actuator). Pneumatic and hydraulic cylinders, or lead screws can be designed to generate force in both directions.Mechanical actuators typically convert rotary motion of a control knob or handle into linear displacement via screws and/or gears to which the knob or handle is attached. A jackscrew or car jack is a familiar mechanical actuator. Another family of actuators are based on the segmented spindle. Rotation of the jack handle is converted mechanically into the linear motion of the jack head. Mechanical actuators are also frequently used in the field of lasers and optics to manipulate the position of linear stages, rotary stages, mirror mounts, goniometers and other positioning instruments. For accurate and repeatable positioning, index marks may be used on control knobs. Some actuators include an encoder and digital position readout. These are similar to the adjustment knobs used on micrometers except their purpose is position adjustment rather than position measurement.Hydraulic actuators or hydraulic cylinders typically involve a hollow cylinder having a piston inserted in it. An unbalanced pressure applied to the piston generates a force that can move an external object. Since liquids are nearly incompressible, a hydraulic cylinder can provide controlled precise linear displacement of the piston. The displacement is only along the axis of the piston. A familiar example of a manually operated hydraulic actuator is a hydraulic car jack. Typically though, the term "hydraulic actuator" refers to a device controlled by a hydraulic pump.Pneumatic actuators, or pneumatic cylinders, are similar to hydraulic actuators except they use compressed air to generate force instead of a liquid. They work similarly to a piston in which air is pumped inside a chamber and pushed out of the other side of the chamber. Air actuators are not necessarily used for heavy duty machinery and instances where large amounts of weight are present. One of the reasons pneumatic linear actuators are preferred to other types is the fact that the power source is simply an air compressor. Because air is the input source, pneumatic actuators are able to be used in many places of mechanical activity. The downside is, most air compressors are large, bulky, and loud. They are hard to transport to other areas once installed. Pneumatic linear actuators are likely to leak and this makes them less efficient than mechanical linear actuators.See also: Ultrasonic motorThe piezoelectric effect is a property of certain materials in which application of a voltage to the material causes it to expand. Very high voltages correspond to only tiny expansions. As a result, piezoelectric actuators can achieve extremely fine positioning resolution, but also have a very short range of motion. In addition, piezoelectric materials exhibit hysteresis which makes it difficult to control their expansion in a repeatable manner.A miniature electromechanical linear actuator where the lead nut is part of the motor. The lead screw does not rotate, so as the lead nut is rotated by the motor, the lead screw is extended or retracted.Pressure-compensated underwater linear actuator, used on a Remotely Operated Underwater Vehicle (ROV)[2]Typical compact cylindrical linear electric actuatorTypical linear or rotary + linear electric actuatorMoving coil linear, rotary and linear + rotary actuators at work in various applicationsElectro-mechanical actuators are similar to mechanical actuators except that the control knob or handle is replaced with an electric motor. Rotary motion of the motor is converted to linear displacement. Electromechanical actuators may also be used to power a motor that converts electrical energy into mechanical torque. There are many designs of modern linear actuators and every company that manufactures them tends to have a proprietary method. The following is a generalized description of a very simple electro-mechanical linear actuator.Typically, an electric motor is mechanically connected to rotate a lead screw. A lead screw has a continuous helical thread machined on its circumference running along the length (similar to the thread on a bolt). Threaded onto the lead screw is a lead nut or ball nut with corresponding helical threads. The nut is prevented from rotating with the lead screw (typically the nut interlocks with a non-rotating part of the actuator body). When the lead screw is rotated, the nut will be driven along the threads. The direction of motion of the nut depends on the direction of rotation of the lead screw. By connecting linkages to the nut, the motion can be converted to usable linear displacement. Most current actuators are built for high speed, high force, or a compromise between the two. When considering an actuator for a particular application, the most important specifications are typically travel, speed, force, accuracy, and lifetime. Most varieties are mounted on dampers or butterfly valves.[3][4]There are many types of motors that can be used in a linear actuator system. These include dc brush, dc brushless, stepper, or in some cases, even induction motors. It all depends on the application requirements and the loads the actuator is designed to move. For example, a linear actuator using an integral horsepower AC induction motor driving a lead screw can be used to operate a large valve in a refinery. In this case, accuracy and high movement resolution aren't needed, but high force and speed are. For electromechanical linear actuators used in laboratory instrumentation robotics, optical and laser equipment, or X-Y tables, fine resolution in the micron range and high accuracy may require the use of a fractional horsepower stepper motor linear actuator with a fine pitch lead screw. There are many variations in the electromechanical linear actuator system. It is critical to understand the design requirements and application constraints to know which one would be best.A linear actuator using standard motors will commonly have the motor as a separate cylinder attached to the side of the actuator, either parallel with the actuator or perpendicular to the actuator. The motor may be attached to the end of the actuator. The drive motor is of typical construction with a solid drive shaft that is geared to the drive nut or drive screw of the actuator.Compact linear actuators use specially designed motors that try to fit the motor and actuator into the smallest possible shape.The inner diameter of the motor shaft can be enlarged, so that the drive shaft can be hollow. The drive screw and nut can therefore occupy the center of the motor, with no need for additional gearing between the motor and the drive screw.Similarly the motor can be made to have a very small outside diameter, but instead the pole faces are stretched lengthwise so the motor can still have very high torque while fitting in a small diameter space.In the majority of linear actuator designs, the basic principle of operation is that of an inclined plane. The threads of a lead screw act as a continuous ramp that allows a small rotational force to be used over a long distance to accomplish the movement of a large load over a short distance.The power supply is from a DC or AC motor. The typical motor is a 12v DC, but other voltages are available. Actuators have a switch to reverse the polarity of the motor, which makes the actuator change its motion.The speed and force of an actuator depend on its gearbox. The amount of force depends on the actuators speed. Lower speeds supply greater force because motor speed and force are constant.One of the basic differences between actuators is their stroke, which is defined by the length of the screw and shaft. Speed depends on the gears that connect the motor to the screw. The mechanism to stop the stroke of an actuator is a limit or micro switch, which can be seen in the image below. Microswitches are located at the top and bottom of the shaft and are triggered by the up and down movement of the screw. Many variations on the basic design have been created. Most focus on providing general improvements such as a higher mechanical efficiency, speed, or load capacity. There is also a large engineering movement towards actuator miniaturization.Most electro-mechanical designs incorporate a lead screw and lead nut. Some use a ball screw and ball nut. In either case the screw may be connected to a motor or manual control knob either directly or through a series of gears. Gears are typically used to allow a smaller (and weaker) motor spinning at a higher rpm to be geared down to provide the torque necessary to spin the screw under a heavier load than the motor would otherwise be capable of driving directly. Effectively this sacrifices actuator speed in favor of increased actuator thrust. In some applications the use of worm gear is common as this allow a smaller built in dimension still allowing great travel length.A traveling-nut linear actuator has a motor that stays attached to one end of the lead screw (perhaps indirectly through a gear box), the motor spins the lead screw, and the lead nut is restrained from spinning so it travels up and down the lead screw.A traveling-screw linear actuator has a lead screw that passes entirely through the motor. In a traveling-screw linear actuator, the motor "crawls" up and down a lead screw that is restrained from spinning. The only spinning parts are inside the motor, and may not be visible from the outside.Some lead screws have multiple "starts". This means they have multiple threads alternating on the same shaft. One way of visualizing this is in comparison to the multiple color stripes on a candy cane. This allows for more adjustment between thread pitch and nut/screw thread contact area, which determines the extension speed and load carrying capacity (of the threads), respectively.Linear screw actuators can have a static loading capacity, meaning that when the motor stops the actuator essentially locks in place and can support a load that is either pulling or pushing on the actuator. This static load capacity increases mobility and speed. The braking force of the actuator varies with the angular pitch of the screw threads and the specific design of the threads. Acme threads have a very high static load capability, while ball screws have an extremely low load capacity and can be nearly free-floating.Generally it is not possible to vary the static load capacity of screw actuators without additional technology. The screw thread pitch and drive nut design defines a specific load capability that cannot be dynamically adjusted.In some cases, high viscosity grease can be added to linear screw actuators to increase the static load. Some manufacturers use this to alter the load for specific needs.Static load capacity can be added to a linear screw actuator using an electromagnetic brake system, which applies friction to the spinning drive nut. For example, a spring may be used to apply brake pads to the drive nut, holding it in position when power is turned off. When the actuator needs to be moved, an electromagnet counteracts the spring and releases the braking force on the drive nut.Similarly an electromagnetic ratchet mechanism can be used with a linear screw actuator so that the drive system lifting a load will lock in position when power to the actuator is turned off. To lower the actuator, an electromagnet is used to counteract the spring force and unlock the ratchet.Dynamic load capacity is typically referred to as the amount of force the linear actuator is capable of providing during operation. This force will vary with screw type (amount of friction restricting movement) and the motor driving the movement. Dynamic load is the figure which most actuators are classified by, and is a good indication of what applications it would suit best.In most cases when using an electro-mechanical actuator, it is preferred to have some type of speed control. Such controllers vary the voltage supplied to the motor, which in turn changes the speed at which the lead screw turns. Adjusting the gear ratio is another way to adjust speed. Some actuators are available with several different gearing options.The duty cycle of a motor refers to the amount of time the actuator can be run before it needs to cool down. Staying within this guideline when operating an actuator is key to its longevity and performance. If the duty cycle rating is exceeded, then overheating, loss of power, and eventual burning of the motor is risked.A linear motor is functionally the same as a rotary electric motor with the rotor and stator circular magnetic field components laid out in a straight line. Where a rotary motor would spin around and re-use the same magnetic pole faces again, the magnetic field structures of a linear motor are physically repeated across the length of the actuator.Since the motor moves in a linear fashion, no lead screw is needed to convert rotary motion to linear. While high capacity is possible, the material and/or motor limitations on most designs are surpassed relatively quickly due to a reliance solely on magnetic attraction and repulsion forces. Most linear motors have a low load capacity compared to other types of linear actuators.Linear motors have an advantage in outdoor or dirty environments in that the two halves do not need to contact each other, and so the electromagnetic drive coils can be waterproofed and sealed against moisture and corrosion, allowing for a very long service life. Linear motors are being used extensively in high performance positioning systems for applications which require various combinations of high velocity, high precision and high force.Rigid chain actuator Telescoping linear actuators are specialized linear actuators used where space restrictions exist. Their range of motion is many times greater than the unextended length of the actuating member.A common form is made of concentric tubes of approximately equal length that extend and retract like sleeves, one inside the other, such as the telescopic cylinder.Other more specialized telescoping actuators use actuating members that act as rigid linear shafts when extended, but break that line by folding, separating into pieces and/or uncoiling when retracted. Examples of telescoping linear actuators include:Helical band actuatorRigid belt actuatorRigid chain actuatorSegmented spindleActuator TypeAdvantagesDisadvantagesMechanicalCheap. Repeatable.No power source required. Self-contained.Identical behavior extending or retracting.Manual operation only. No automation.Electro-mechanicalCheap. Repeatable.Operation can be automated. Self-contained.Identical behaviour extending or retracting.DC or stepping motors. Position feedback possible.Many moving parts prone to wear.Linear motorSimple design. Minimum of moving parts.High speeds possible. Self-contained.Identical behavior extending or retracting.Low to medium force.PiezoelectricVery small motions possible at high speeds.Consumes barely any power.Short travel unless amplified mechanically.High voltages required, typically 24V or more.Expensive and fragile.Good in compression only, not in tension.Typically used for Fuel Injectors.TCP: Twisted andcoiled polymerlight and inexpensiveLow efficiency and High temperature range requiredHydraulicVery high forces possible.Relatively high power to size ratio (or power density).Can leak. Requires position feedback for repeatability.External hydraulic pump required.Some designs good in compression only.PneumaticStrong, light, simple, fast.Precise position control impossible except at full stopsWax motorSmooth operation.Not as reliable as other methods.Segmented spindleVery compact.Range of motion greater than length of actuator.Both linear and rotary motion.Moving coilForce, position and speed are controllable and repeatable.Capable of high speeds and precise positioning.Linear, rotary, and linear + rotary actions possible.Requires position feedback to be repeatable.MICA: Moving ironcontrollableactuatorHigh force and controllable.Higher force and less losses than moving coils.Losses easy to dissipate.Electronic driver easy to design and set up.Stroke limited to several millimeters,less linearity than moving coils.Helical band actuatorHoist Device used for lifting or lowering a loadRack and pinion Type of linear actuatorSolenoid Type of electromagnet formed by a coil of wire^ Sclater, N., Mechanisms and Mechanical Devices Source book, 4th Edition (2007), 25, McGraw-Hill^ "Underwater Linear Actuator". Ultra Motion. 22 October 2014.^ "Linear Actuator Guide", Anaheim Automation, retrieved May 12, 2016^ "Electric Actuators", Baelz Automatic, retrieved May 12, 2016Wikimedia Commons has media related to Linear actuators.Leo Dorst's Lego linear actuatorRetrieved from " A linear actuator is a device that converts rotary motion into linear motion, enabling movement in a straight line. These actuators are widely used in automation, robotics, medical equipment, industrial machinery, and smart home systems.In this article, we will explore:What is a linear actuator?How does a linear actuator work?Types of linear actuatorsApplications in different industriesHow to choose the right linear actuator? What is a Linear Actuator?A linear actuator is a mechanical device that generates linear (straight-line) motion from a power source (electricity, hydraulics, or pneumatics). Unlike rotary actuators, which create rotational movement, linear actuators push, pull, lift, or slide objects in a controlled manner.Key Features of Linear Actuators: Converts rotary motion into linear motion High precision and control Can be electric, hydraulic, or pneumatic Used in automation, robotics, medical devices, and more How Does a Linear Actuator Work?The working principle of a linear actuator depends on the type of actuator. The most common type is the electric linear actuator, which operates as follows:Electric Motor Activation A DC or AC motor generates rotational motion.Gear Reduction Mechanism A gear system reduces speed and increases torque.Lead Screw or Ball Screw Mechanism Converts rotational motion into linear motion.Extension & Retraction The actuators rod or slider moves forward or backward.Limit Switches & Sensors Control the motion range and positioning. Example: In an adjustable hospital bed, an electric linear actuator raises or lowers the bed by extending or retracting a lead screw mechanism. Types of Linear ActuatorsThere are several types of linear actuators, each suited for different applications:1. Electric Linear ActuatorsPower Source: DC or AC electricityMechanism: Uses a motor, lead screw, and gearsAdvantages: Precise control, programmable, energy-efficientApplications: Smart furniture, medical devices, automation2. Hydraulic Linear ActuatorsPower Source: Hydraulic fluid pressureMechanism: Uses a piston and cylinder systemAdvantages: High force output, suitable for heavy loadsApplications: Construction equipment, industrial presses3. Pneumatic Linear ActuatorsPower Source: Compressed airMechanism: Uses a piston in a sealed cylinderAdvantages: Fast response time, lightweightApplications: Factory automation, packaging machinery4. Stepper & Servo Motor Linear ActuatorsPower Source: Stepper or servo motorMechanism: Ball screw or belt-driven systemAdvantages: High accuracy, programmable motionApplications: Robotics, CNC machines, 3D printers Applications of Linear ActuatorsLinear actuators are used in a wide range of industries, including:1. Industrial Automation & MachineryConveyor systemsCNC machinesMaterial handling robots2. Medical & Healthcare EquipmentAdjustable hospital bedsWheelchairs and patient liftsDental chairs3. Smart Home & FurnitureMotorized TV liftsElectric standing desksAutomated window blinds4. Automotive & TransportationCar trunk openersElectric seat adjustmentsAdaptive suspension systems5. Renewable EnergySolar panel tracking systemsWind turbine blade adjustments How to Choose the Right Linear Actuator?To select the best linear actuator for your application, consider the following factors: Load Capacity Determine the weight the actuator must move. Speed & Stroke Length Choose the required movement speed and distance. Power Supply Select AC/DC depending on power availability. Environment Ensure durability for outdoor or harsh conditions. Control System Consider manual, remote, or automated control. Example: If you need a quiet and smooth actuator for an electric recliner, an electric linear actuator with a low-noise motor is ideal. ConclusionA linear actuator is an essential component in modern automation, providing precise and efficient linear motion. Whether used in industrial machines, medical devices, smart homes, or robotics, these actuators offer high performance, reliability, and control.If youre looking for high-quality linear actuators, visit Changxing Motion Tech to explore their advanced actuator solutions. Frequently Asked Questions (FAQs)1. What is the lifespan of a linear actuator?Most electric actuators last several years with proper maintenance, typically 10,000 to 100,000 cycles.2. Can I control a linear actuator with Arduino?Yes! You can use an Arduino board with an H-bridge motor driver to control an electric linear actuator.3. What is the maximum force a linear actuator can handle?It depends on the type. Electric actuators can handle 100N to 10,000N, while hydraulic actuators can go beyond 100,000N.4. Are linear actuators waterproof?Some models have IP-rated protection (e.g., IP65, IP67) for outdoor and wet environments.5. Can I use a linear actuator in extreme temperatures?Yes! Some actuators are designed for hot, cold, or harsh industrial environments. Why Choose Changxing Motion Tech for Linear Actuators? High-Quality & Durable Products Customizable Actuator Solutions Reliable Performance & Precision Industry Expertise & Support Need help choosing the right actuator? Contact Changxing Motion Tech today! Home > Blog > How Do Linear Actuators Work? Linear actuators are the driving force behind countless machines and automated systems. They convert energy into straight-line motionideal for pushing, pulling, lifting, or positioning objects with precision. Whether you're automating a TV lift, opening a hidden compartment, or building robotics, understanding how linear actuators work is the first step to mastering motion control. A linear actuator is a device that converts rotary motion (typically from an electric motor) into linear motion. Unlike hydraulic or pneumatic actuators, electric linear actuators use electricity to create movementmaking them cleaner, quieter, and more precise.TV lifts and pop-up cabinetsAutomated windows and hatchesIndustrial automation systemsRobotics and aerospaceMedical equipment and home accessibilityCore Components of an Electric Linear ActuatorDC or AC Motor: Generates rotary motionGearbox: Reduces speed and increases torqueLead Screw or Ball Screw: Converts rotary to linear motionDrive Nut: Attached to the rod and rides the screwExtension Rod: Moves in and outLimit Switches: Prevent overtravelHall Sensor (optional): For position feedbackHow the Mechanism WorksThe motor spins the lead screw, moving the internal nut. As it moves, it extends or retracts the rod, generating controlled linear motion. Limit switches shut off movement at either end of the stroke.Types of Linear Actuators Advantages of Electric Linear ActuatorsPrecision control and clean operationNo leaks or fluids to manageQuiet and compact designEasy integration with Arduino or PLCsReal-World ExampleA FIRGELLI actuator mounted in a cabinet lifts a hidden TV when powered. It stops at full extension automatically, and retracts just as smoothly with the press of a button.How to Choose the Right ActuatorFactors to consider:Force, stroke, speed, voltageFeedback requirementsEnvironment and IP ratingUse our Linear Actuator Calculator to find the right model.Frequently Asked QuestionsHow do I wire a linear actuator?Two wires control direction via polarity. Use a DPDT switch or relay. Wiring GuideCan I run multiple actuators together?Yes. For synchronized motion, use a sync controller with hall sensors.Whats the difference between track and rod-style?Track actuators dont extend outwardideal where space is limited. Compare hereIs electric better than hydraulic or pneumatic?In many use cases, yesdue to simplicity, safety, and precision.Explore Further How they work Which Actuator to use Actuator Speed Deep Dive: How Linear Actuators Really WorkIf you read the previous section, we covered Actuators at the high level, for those that want to go into more detail, we cover that in this section below:Many people, rather,most people have never needed to use an actuator before, and typically refer to them as 'rams', 'activators', 'electric pistons', or other wild variations. All in all, they all mean the same thing, and we don't mind if you don't like using the technical terms. First thing to know, is that a linear actuator does exactly what its name implies: itactuates (or 'moves') in alinear(or 'straight') fashionThere are many different ways that a motor can do this, and their motion is commonly achieved with a rod extending and retracting, or a slider which moves on a track. Uses for these linear motors vary widely, and they can be used on everything from TV lifts (including drop down lifts), wheelchair ramps, industrial machinery, toys, office and home automation, and even aerospace technology.So how does a Linear Actuator work?The Linear motion is created by using a screw or Lead-scew as they are more correctly called. The screw turns either clockwise or counter-clock-wise and this causes the shaft, which is basically a nut on the screw to move up and down the screw as the screw turns. This is what convert rotary motion from the electric motor to linear motion.The motors used are either AC or DC motors, most however run on 12v dc, but other voltages are also optional. To make the Actuator go the other way you simple reverse the wires from the Actuator (reverse polarity) from the battery or power supply. This is typically done through a switch that automatically reverses the polarity to the motor for you.Different speeds and forces are achieved by using different gear ratio's inside the linear actuator gearbox system. Please remember in a Linear Actuator, force and speed trade-off against each other. That means if you want high force you have to settle for a lower speed than if you require lower force. This is because the only constant in a Linear Actuator is the Motor speed and force for a given input voltage. Everything after the motor is what is available to be used to create speed and force.Actuators are available in different strokes, all this means is the screw and shafts are longer or shorter to get the stroke you want. They are also available in different speeds and forces. This is achieved by simple changing the gears that go between the DC motor and the screw. Typically the faster the screw turns the lower the force, because speed and force trade-off against each other.To make the shaft stop when it gets to the end of the stroke the Actuators have built in limit switches or micro switches as they are sometime known. These limit switches are inside the main actuator shaft and are nothing more than a small switch that are triggered by the nut inside that slides up and down the screw. There is one for the top extended position and one for the lower retracted position. Once the limit is reached the switch is triggered and cuts power to the DC motor. Only if the polarity is reversed can the actuator move which would be in the opposite direction. Without any power the actuator cannot more at all.Firgelli Automations is a proud supplier for thousands of companies in the above sectors, and more for over fifteen years. In these years, we've learned a thing or two about what first-timers want to know. This will be a regularly updated article with all the links and videos you could possibly need to start your own project with actuators.What Actuator should I use?With such a selection of Actuators we manufacture, it can be very easy to get confused and frustrated if you don't know anything about electric motors or actuators in particular. Typically when helping a new client choose the right unit for his or her application, we will ask the following:What are you using it for?How much force do you need?How much stroke ('travel') do you need?How fast do you need it to move?And finally, how often do you need it to do this?The significance of these questions is to determine what sort of load will be placed on your future actuator, and what requirements you have. Most people start off with needing a product withX amount of force, which is a fantastic place to begin your search. The Actuator finder page will help you pick the right unit based on force, and narrow your search down, or use our Linear Actuator Force Calculator to determine what force of Actuator you really need. Typically we would recommend a certain type of actuator based on what you tell us you're using it for, but for those of you who are just tuning in, see below for common applications for various types of actuators and see if you can pick your project out.Track Actuators - Used for tight spaces where a sliding block is ideal due to its unchanging retracted and extended length.Rod-Style Actuators - These are the most common actuators you will find, and simply feature a shaft which extends and retracts, providinglinear motion.Feedback Actuators -For applications which have systems to read the actuators' position, these potentiometer pod equipped actuators are ideal; they provide accurate information for precise control over your application.Now that you know how much force you need, and an idea of what type of actuator you require, we can move on to the next step of determining what stroke length you'll be wanting.How long should an Actuator be?Here is where most people get slightly miss-informed. The difference between the open and closed position for an actuator is simply known as the 'stroke length'. For example, if we had a to move a sliding block twelve inches, we would want to make sure that the actuator we chose for the job would have astroke length of at least twelve inches.Do I need a High Speed Actuator?So to re-cap: You know now how much force you need, as well as the type of actuator you'll be using and the stroke length. Finally you are now ready to figure out the speed of the actuator. Most of the product lines found on our site feature several different forces, this is important because within those product lines, as you increase in force, you decrease in speed due to varying gear ratios, much like the transmission in a car. So by now you've narrowed your selection down to one or maybe two product lines that we carry. At this point, it is a good idea to go to the 'Specifications' tab of each unit and have a look at their speed rating. Keep in mind, speed ratings are assuming the unit is being used at full load.You're now equipped with the thought process that the pro's in large scale engineering projects follow on a daily basis. If you have further questions or concerns, you will find a wealth of helpful staff at the ready via email or phone on our contact page.Watch Videos and Read Articles on Linear Actuators Below Sorry to interruptCSS Error In this article, were going to help you understand what are linear actuators and how linear actuators work. Linear actuators are complex pieces of technology that are used in thousands of applications across industries. Understanding how linear actuators work can help you choose how to integrate them into your product or projects. A linear actuator is a device that is used for creating linear motion, in contrast to the rotary motion created by a standard electric motor. Linear actuators convert the rotary motion of an electric motor to linear motion, saving product designers the hassle of engineering a solution themselves. While actuators are complex devices, they simplify the task of creating reliable linear motion. How Does a Linear Actuator Work? Linear actuators are controlled through a variety of methods, typically involving electronic signals. Covering every possible control method is outside the scope of this article, but we will touch on the more common ones below. DC Control. DC voltage is applied directly to the motor through a switch, relay, or other mechanism. Changing the polarity of the voltage supply allows the actuator to change direction. Pulse Width Modulation (PWM). Switching a digital signal on and off produces the equivalent of an analog DC signal, which can command an actuator to move to a certain position. Varying the signals on-time vs. off-time (pulse width) will command the actuator to different positions. This is a common control method when using microcontrollers in embedded systems. PLCs (Programmable Logic Controllers). PLCs are popular control systems in many fields, including industrial automation. They can drive linear actuators with a variety of control signals, including 4-20mA current loops. Servo Control. Some actuators operate as direct plug and play replacements for standard rotary servos. This type of control is compatible with arduino as well as most hobbyist radio control systems. Some linear actuators integrate feedback sensors, such as encoders or hall-effect sensors, which provide real-time information about the actuator's position, allowing for closed-loop control and enhanced accuracy. Linear actuator performance is influenced by several key factors. These include but are not necessarily limited to: The design and quality of the components, such as gearboxes or lead screws. This can affect the smoothness of the motion and the overall precision of the device. The choice of materials for guides and housing impacts durability and friction. Feedback systems, like sensors and limit switches, play a role in accurate positioning and safety. Voltage and current control mechanisms on the power source influence the actuator's speed, force, and responsiveness capabilities. Environment conditions. Such factors as temperature, humidity, and load weight can impact an actuator's efficiency and longevity Different Types of Linear Actuators Explained Electric Linear Actuators: Screw, Belt, Linear Motor Hydraulic and Pneumatic Linear Actuators Mechanical Linear Actuators: Cam, Wheel, and Axle Common Questions About Linear Actuators Generally, it is best to avoid side-loading a rod-style linear actuator. If you have an application where a side load can not be avoided, you have a couple of options. Mounting the load on a linear slide rail and then driving the rail with a rod actuator is one choice to avoid side loading. Another option, if your design permits, is to use a track actuator which is more tolerant of side-loading. Actuonix actuators are supplied with a free mounting kit that is compatible with the type of actuator that you have ordered. It is always advised to load a linear actuator in accordance with the manufacturers recommendations. Overloading a linear actuator can result in overheating, slow or stalled movement, mechanical failure, and reduced actuator life. Some linear actuators have limit switches. If the actuator you intend to use does not come with limit switches and you would like to use the, an external limit switch kit can be used. The future outlook for linear actuator applications is promising, driven by ongoing advancements in automation, robotics, and precision engineering. As industries continue to demand higher levels of accuracy, efficiency, and adaptability, linear actuators are poised to evolve accordingly. Smart actuators equipped with sensors and integrated electronics will become more commonplace, enabling real-time feedback, adaptive control, and predictive maintenance. This convergence of actuators with the Internet of Things (IoT) will lead to interconnected systems capable of self-optimization and remote monitoring, enhancing overall operational efficiency. Additionally, developments in materials science will result in actuators that are more durable, lightweight, and energy-efficient, ultimately extending their lifespan and reducing their environmental impact. The miniaturization of linear actuators will persist, especially in fields like medical devices and micro-robotics, enabling intricate movements in confined spaces. As industries explore greener and more sustainable technologies, linear actuators will continue to play a vital role in achieving energy-efficient automation and enabling a wide range of innovative applications across sectors such as manufacturing, healthcare, aerospace, and beyond. Actuonix provides linear actuators for a wide range of industries, allowing technology to keep up with our clients imagination. Browse actuators by model today and reach out to us with questions or to submit an order. This includes everything you need to know about linear actuators. You will learn: What is a Linear Actuator? Types of Linear Actuators How Does a Linear Actuator Work? Linear Actuator Design And much more A linear actuator transforms rotary motion into straight-line movement, permitting the lifting, lowering, sliding, or tilting of equipment or materials. They provide efficient, clean, and maintenance-free motion control solutions. Electric linear actuators utilize either a DC or AC motor coupled with a gear assembly and lead screw system to extend or retract the primary rod shaft. The motor size differentiates various actuators, with options ranging from 12V DC to 48V DC. Key considerations for linear actuators include their static and dynamic load capacities. Dynamic load capacity indicates the force it can handle while in operation, whereas static load capacity pertains to the force it can support when stationary and maintaining a load. The adhesive applicator depicted in the diagram employs an actuator to automate the adhesive application process, a task formerly performed manually. Actuators are essential for automating tasks such as opening automatic doors, adjusting car seats, and controlling computer disk drive mechanisms. Essentially, a linear actuator operates on the principle of an inclined plane, where the lead screw utilizes minimal rotational force to move up or down the ramp. Chapter Two Types of Linear Actuators Linear actuators are essential machine components designed to provide precise linear motion and positioning control in countless industrial automation and engineering applications. Available in a wide range of configurations, linear actuators are tailored to fit specific requirements across diverse industriesincluding manufacturing, robotics, medical devices, automotive systems, and material handling. They are typically categorized based on their mechanical drive mechanism (such as screw, belt, or rack and pinion), motion guide system, and housing design. Selecting the optimal linear actuator type involves evaluating load capacity, speed, stroke length, accuracy, environmental conditions, and control system requirements. Below, we examine and compare several common types of linear actuators, outlining their features and ideal uses to help you make an informed purchasing decision. Types of Linear Actuators Mechanical Actuators Mechanical actuators are the most fundamental form of linear actuators, converting rotary motion into controlled linear displacement. Key types of mechanical actuators include ball screw actuators, lead screw actuators, rack and pinion actuators, belt-driven actuators, and cam actuators. Ball screws and lead screws offer high efficiency and accuracy, making them popular choices for motion control applications like CNC machinery, precision assembly systems, automated testing equipment, and pick-and-place robots. Belt-driven actuators are ideal for high-speed and long-stroke applications, while rack and pinion mechanisms provide high force linear movement suitable for heavy-duty tasks. Below are examples of mechanical actuators from Venture Mfg. Co. in Dayton, Ohio. Hydraulic Actuators Hydraulic actuators, also known as hydraulic linear actuators, utilize pressurized, incompressible hydraulic fluid to generate significant linear force and displacement via an internal piston-cylinder assembly. This hydraulic system configuration enables precise control over powerful, smooth motion, even under heavy-duty loads. Traditional hydraulic cylinders are commonly deployed in construction machinery, material handling equipment, automotive industrial presses, and marine systems. The pictured hydraulic actuator demonstrates how pressurized fluid enters through a port in the cylinder, moving the piston and actuating the required linear motion. When pressure is released or redirected, the piston returns to its initial position, completing the cycle. Hydraulic actuators are valued for their robust force output, continuous-duty capability, and excellent durability in demanding or harsh environments. Typical applications include injection molding machines, excavators, industrial presses, lift gates, and aerospace control surfaces. Pneumatic Actuators Pneumatic actuators rapidly generate low to medium force and are commonly used as servo devices in automation systems. Pneumatic linear actuators utilize compressed air to convert pneumatic energy into controlled mechanical motion. These actuators feature a piston, cylinder, and control valve or port, providing either precise linear or rotary actuation. Pneumatic actuators offer fast cycle speeds, low friction, and reliable operation, making them well suited for automated conveyor systems, pick-and-place robotics, packaging equipment, medical devices, and textile automation. When evaluating pneumatic actuators, consider the required stroke length, speed of actuation, load rating, and air consumption. Pneumatic actuators are ideal for environments where electric or hydraulic systems may be impractical due to explosive or wet conditions, or where rapid cycling is essential. Piezoelectric Actuators Piezoelectric actuators harness the piezoelectric effect, generating precise and rapid motion by applying electrical voltage to piezoelectric materialsoften advanced ceramics or crystals. This electromechanical effect enables exceptionally accurate and responsive movement at micro- or nano-scale levels, making piezo actuators indispensable in high-precision positioning systems, optical devices, medical equipment, and semiconductor fabrication. The stacked piezoelectric actuator depicted below can quickly open or close valves with extraordinary repeatability and control, ideal for micro-dosing, scanning microscopy, and precision instrumentation. Benefits of piezoelectric linear actuators include high resolution, fast response time, lack of mechanical backlash, and low power consumption. When selecting piezo actuators, consider the operating voltage, stroke length, and the actuator's load capacity in specialized applications. Coiled Actuators Coiled actuators, also known as voice coil actuators or linear solenoids, use electromagnetic force to generate non-contact, friction-free motion. Current passing through a movable coil placed within a magnetic field creates force and displacement in a shaft or shuttle. By increasing the number of coil turns, current intensity, or the strength of the magnetic field, the force output can be finely adjusted for the applications requirements. These actuators are valued for fast acceleration, smooth motion, and precise force control and are often selected for applications such as vibration testing, autofocus systems, medical pumps, and high-speed sorting machinery. Electro-Mechanical Actuators Electro-mechanical actuators deliver high-precision linear motion and force by integrating electric motorssuch as DC brushless, AC servo, or stepper motorswith mechanical drive systems like ball screws or lead screws. These programmable actuators can deliver precise stroke lengths, force profiles, and speed control, making them essential in modern industrial automation, robotics, laboratory instruments, CNC platforms, packaging machinery, and process control systems. Electro-mechanical actuators are available in several configurations, including simplified, standard, and compact designs to meet various space and performance requirements. Advantages of electro-mechanical linear actuators include easy integration with industrial PLCs and motion controllers, energy efficiency, minimized maintenance needs, and excellent versatility in both force and speed tuning. When sourcing electro-mechanical actuators, assess factors such as actuator feedback options, mounting styles, environmental protection ratings (IP ratings), and integrated control capabilities. Telescoping Actuators Telescoping actuators are specially designed for applications with restricted installation space and the need for extended reach. Available in configurations such as rigid belt, segmented spindle, rigid chain, or helical band, telescoping linear actuators employ retractable sectionsoften tubes of equal length that nest within each other (much like a handheld telescope). Their standout feature is delivering a long stroke length relative to the actuators compact retracted size, optimizing footprint and maximizing motion range in confined spaces. Common applications for telescoping actuators include medical beds, adjustable workstations, lifting columns, stage platforms, and automated storage and retrieval systems. When specifying telescopic actuators, consider cycle frequency, load ratings, stroke requirements, and the actuator's integration with safety devices. Ball Slide Ball-guided linear slidesalso known as ball slide actuators or linear bearingsprovide high precision, accuracy, and stiffness for demanding industrial and scientific applications. These slides use precision-ground tracks and preloaded ball bearings to ensure low friction, smooth and repeatable linear motion, and minimized wear even under high cycling or varying loads. Their non-magnetic construction makes them particularly well-suited for electronic testing, medical imaging, semiconductor manufacturing, and environments where magnetic fields could cause interference. When selecting a ball slide for your application, be sure to consider factors like load capacity, travel accuracy, slide material, size, preloading force, and environmental resistance. Common uses range from coordinate measuring machines and optical inspection systems to micro-assembly and scientific research instrumentation. Chapter Three How Does a Linear Actuator Work? A linear actuator is a precise mechanical device that creates motion in a straight line, as opposed to the rotational motion provided by conventional electric motors. As a fundamental mechanism in many automation solutions, linear actuators are essential in countless applications, ranging from automated wheelchair ramps and interactive toys to specialized equipment in robotics, factory automation systems, and advanced aerospace technology. The core function of a linear actuatorconverting electrical, hydraulic, or pneumatic energy into linear mechanical motionremains consistent across its wide variety of configurations, making these devices indispensable for businesses seeking dependable linear movement. The operation of an actuator involves converting input energy into controlled linear displacement. This is typically achieved using mechanical actuating systems such as lead screws, ball screws, or roller screws, chosen based on required actuator specifications like load rating, speed, and accuracy. When the screw rotates (either clockwise or counterclockwise), it causes a traveling nut to move along its length, generating linear push or pull movement. Ball screw actuators are especially suitable for high-speed, dynamic operations requiring tight precision and minimal friction, while roller screw actuators excel in applications demanding extremely high thrust and load capacity, such as heavy machinery, presses, or industrial automation systems. The motion of the screw in a linear actuator is clearly illustrated in the diagram below. The integrated motor, positioned above the actuator assembly, supplies the necessary torque and energy for screw rotation, transforming electrical energy into powerful, controlled linear action. The power supply for a linear actuator can originate from a diverse range of motors, most commonly either DC or AC electric motors. Standard voltages for electric actuators typically include 12V DC, 24V DC, 36V DC, and 48V DC, with bespoke options available for specialized uses. Brush DC actuators employ internal switchessuch as relays or H-bridge circuitsto reverse motor polarity, effectively changing the actuators direction. Advanced actuation applications often feature servo motors, stepper motors, or brushless DC (BLDC) motors, which require dedicated electronic controllers for precise position feedback and commutation; feedback devices like hall effect sensors, optical encoders, or potentiometers are used to accurately regulate stroke, force, and speed. Control electronics may be externally mounted or embedded within the linear actuator, allowing for seamless integration into modern control systems, including programmable logic controllers (PLC) or industrial IoT platforms. The speed and force capabilities of any linear actuator are significantly impacted by its internal gearboxan arrangement that determines the ratio of force to speed. In general, a gearbox designed to reduce the output speed will simultaneously increase available thrust, ensuring the actuator generates ample force to move heavy loads in industrial and commercial settings. This critical relationship between speed (travel rate) and force (load capacity) directly impacts actuator selection for applications such as medical devices, industrial automation, or ergonomic workstations, where optimized motion performance is key. One of the essential parameters distinguishing one actuator from another is stroke length, which refers to the maximum distance a linear actuator can extend or retract. This is governed by the length of the screw and shaft, and must be matched to the specific requirements of each application for optimal performance and efficiency. Gear assemblies and motor selection further influence actuator dynamics, affecting both travel speed and accuracy. For safety and precise positioning, various motion control mechanisms and feedback systems are integrated into linear actuators. Common methods to stop or detect the end of stroke include mechanical or electronic limit switches, micro switches, rotary or linear encoders, potentiometers, and linear variable differential transformers (LVDTs). A micro switch, demonstrated in the image below, is commonly installed at both ends of the actuator shaft and is triggered by the travel of the screw to reliably stop movement when the actuator reaches its extension or retraction limit. Components of a Linear Actuator Power Source The power source is the driving force behind linear actuator operation and can be an electric (AC or DC), pneumatic, or hydraulic motor depending on application requirements. While electric actuators using AC or DC motors are most common due to ease of control and efficiency, pneumatic (air-driven) and hydraulic (fluid-driven) actuators are indispensable in heavy-duty, industrial manufacturing environments where very high forces and rapid actuation are required. Choosing the appropriate actuation technology ensures optimal performance, energy savings, and long service life. Power Converter Power converters play a vital role in regulating and adapting energy delivery to the actuator. These devices, such as industrial voltage converters, hydraulic proportional valves, and electrical inverters, help optimize actuator response, efficiency, and compatibility with automation systems. Accurate power conversion ensures smooth and reliable linear movement, reducing energy waste and prolonging the lifespan of actuator components. Actuator The actuator itself is the mechanical device responsible for transforming input energy (electrical, pneumatic, or hydraulic) into controlled, repeatable linear motion. Depending on the designelectric linear actuators, pneumatic cylinders, or hydraulic ramsactuators provide tailored functionality for automation, robotics, industrial machinery, medical equipment, and more. Factors such as construction materials, ingress protection (IP) rating, and actuator mounting options further determine suitability for specific environments and tasks. Mechanical Load The mechanical load is the total force or weight the actuator must move or support during operation. Precise load calculation is essential for optimal performance and reliability and often references standard specifications or load charts provided by the manufacturer. Both static load (force applied when stationary) and dynamic load (force required during movement) must be considered, especially for safety-critical or high-duty cycle automation applications. Understanding load types also aids in selecting actuators with appropriate duty cycles, self-locking features, and overload protection. Controller The controller is a key component in modern actuator systems, providing logic processing, motion control, and user interface functions. Operators use the controller to set motion profiles, positions, and set-points while advanced control solutions integrate with PLCs or software-driven HMI interfaces. Todays controllers increasingly support automation protocols and remote monitoring, enabling real-time status updates, diagnostics, and predictive maintenance. Phase Index Sensor Modern advancements in actuator feedback technology are exemplified by the innovative Phase Index sensor. This digital, high-speed, high-resolution, non-contact positioning sensor is engineered specifically for electromechanical actuators where durability, accuracy, and reliability are paramount. Due to its robust, vibration- and shock-resistant design, and its resilience to moisture and dust, the Phase Index sensor is ideal for industrial automation, mobile robotics, and harsh-environment positioning systems. Its self-calibrating capability eliminates the need for backup power, ensuring the actuators position is retained even in power outage scenariossupporting instant readiness and decreased system downtime. The Power Index sensor determines position by analyzing the phase relationship between two cyclic signals with differing periods. The benefits of this sensing technology include exceptional positioning accuracy, maintenance-free operation, and reliable performanceeven in hostile or stressful manufacturing environmentsthanks to its patented sensor mechanism. As a result, the Phase Index sensor enhances feedback precision and lifecycle value in high-performance linear actuator systems. How to Choose the Right Linear Actuator for Your Application Selecting the optimal linear actuator for your specific needs involves considering several key selection criteria. Critical factors include load capacity (thrust), stroke length, travel speed, duty cycle, available mounting space, environmental conditions, and required position accuracy. For applications in industrial automation, robotics, or adjustable furniture, consider actuator types such as electric actuators, hydraulic linear actuators, or pneumatic actuators, each offering unique advantages in motion control, efficiency, and cost. Always compare actuator specifications, options for integrated control systems, and available feedback mechanisms to ensure compatibility and peak performance for your intended motion control solutions. Common Uses and Benefits of Linear Actuators Linear actuators are trusted across a broad spectrum of industries, including manufacturing, medical technology, automation, packaging, electronics, and automotive engineering. Their ability to provide precise, programmable, and maintenance-friendly motion makes them the ideal solution for automation and positioning requirementsfrom packaging conveyors and adjustable hospital beds to solar tracking systems, robotics platforms, and laboratory automation devices. With advancements in sensor technology and controller integration, modern actuators enable higher productivity, increased reliability, and reduced maintenance costs, driving innovation in today's automated systems. If you are exploring automation solutions, understanding the working principles, types, components, and key performance considerations for linear actuators is crucial for specifying the right actuator and ensuring reliable, efficient operation in your specific application. Chapter Four Linear Actuator Design Linear actuators are designed for efficiency and ease of use. Their design is based on the inclined plane principle, starting with a threaded lead screw that acts as a ramp. This setup produces force over a greater distance to move the load effectively. The purpose of any linear actuator design is to provide push or pull motion. This motion can be powered either manually or through an external energy source, such as air, electricity, or fluid. Linear Actuator Design Power Power is the primary consideration when designing a linear actuator. To achieve mechanical power output, an input power source is required. The amount of mechanical power output is defined by the force or load that needs to be moved. Manufacturers provide data on performance graphs and charts, detailing factors such as force (F), speed (V), and current draw (I), which indicate the load capacity of the actuator. Duty Cycle The duty cycle refers to how often the actuator operates and the duration of its operation. It is influenced by the actuator's temperature during use, as power loss occurs through heat. Adhering to duty cycle guidelines helps prevent overheating of the motor and protects the actuator's components from damage. Since not all actuators are identical, their duty cycles can vary. Factors affecting the duty cycle include the load, especially for DC motors, as well as ambient temperature, loading characteristics, and the age of the actuator. Efficiency Understanding the efficiency of an actuator is crucial for assessing its performance in operation. For a ball screw actuator, its efficiency will indicate whether holding brakes are necessary. Efficiency is calculated by dividing the mechanical power produced by the electrical power supplied. The resulting ratio is expressed as a percentage, representing the actuator's efficiency rating. Actuator Life Several factors influence the lifespan of an actuator. Proper care and maintenance, similar to other industrial tools, play a significant role in extending its longevity. Some factors that can help extend the life of an actuator include: Staying within the rated duty cycle The duty cycle represents a balance between usability and lifespan. The chart below, provided by Actuonix Motor Devices, illustrates a typical duty cycle example. Minimize side load Actuators are designed for push and pull motions, and side loading can significantly reduce their effectiveness. Internal friction caused by side loading can quickly wear out the actuators components. If side loads are unavoidable, using a slide rail with the actuator can help extend its lifespan. Staying within the recommended voltage Applying more voltage than recommended may cause the actuator to run faster temporarily, but it will lead to quicker wear and reduced lifespan. Force Each actuator has a defined load capacity, such as 20 pounds. Operating it below its maximum rated capacity will help extend its lifespan. Extreme environments While most actuators are designed for industrial settings, it is best to avoid exposing them to extreme heat, cold, dirt, dust, or moisture. For moist conditions, there are actuators specifically designed to operate underwater. The actuator below, from Ultramotion, is engineered for underwater use. Chapter Five Load Capacity Linear actuators can be used for tension, compression, or both, to generate pushing or pulling forces. The load capacity of a linear actuator is measured in two ways: dynamic and static. Dynamic load capacity refers to the actuator's performance while it is in motion, whereas static load capacity refers to its ability to hold a load in a fixed position without movement. The load capacity of a linear actuator is determined by its ability to move and hold a load. Loading refers to the forces applied to the actuator, including both compressive forces that push towards it and tensile forces that pull away from it. Dynamic load capacity is a test that measures the number of revolutions of linear motion a linear actuator can achieve before experiencing fatigue, which is identified by flaking on rolling elements and the rated life of these elements. The International Organization for Standardization (ISO) standard 14728-1:2017 outlines the guidelines for assessing load fatigue in linear actuators. The dynamic, working, or lifting load capacity refers to the force applied to the linear actuator while it is in motion. This capacity determines the actuator's ability to move an object and is the load it will handle while powered, extending, or retracting. It indicates how much force the actuator can push or pull during operation. When a load is in a static position, it is fixed or stationary and not moving. Static load capacity measures how much weight an actuator can safely support without back driving or sustaining damage. Chapter Six Uses for Linear Actuators Modern linear actuators resemble their early designs but have benefited greatly from technological advances. These improvements have enhanced production precision and power sources. Advancements in engineering, materials, technology, and physics have expanded the use of linear actuators into a wide range of industries and applications. Though they often go unnoticed, linear actuators are present in many everyday environments, including stores, offices, and schools. They have become integral to technological advancements and development. Uses for Linear Actuators Space exploration In space exploration, every component of the vehicle must be optimized for maximum utility while minimizing weight. Micro linear actuators are crucial in this regard, saving space and performing essential tasks. They are employed for operating robotics, opening and closing valves, tracking, securing locking systems, and moving robotic arms. Automobiles One of the most common applications of linear actuators in cars is for powered tailgates. Self-opening and closing tailgates have become highly popular and convenient. Additionally, linear actuators are used for opening and closing side doors and activating air brakes. Medicine Linear actuators are integral to advanced medical equipment. They play a crucial role in healthcare by facilitating patient lifting and positioning. For example, linear actuators in beds and chair recliners allow healthcare personnel to easily adjust the height of the bed for patient treatment. Additionally, monitoring equipment, such as ventilators and temperature control devices, often uses linear actuators to adjust their height and positioning. Snowblower One common issue with operating a snowblower is the need to frequently adjust the direction of the chute. Since operating a snowblower requires both hands, reaching to change the chute's position can be challenging. A recent advancement in linear actuator technology addresses this by incorporating a switch that allows the chute's position to be adjusted with a simple thumb press. The snowblower pictured below features a linear actuator on its side for convenient and easy repositioning of the chute. Robotics The automotive industry leverages robotics to enhance production quality and accuracy while managing production costs. Electric linear actuators play a key role by controlling and repeating precise movements, regulating acceleration and deceleration rates, and managing the required force. In bar feeders, actuators combined with controllers are used to insert rods into the machine and adjust their height for optimal positioning. Rodless actuators are also utilized to move pallets and position lumber for cutting and packaging. Chapter Seven How to Choose a Linear Actuator Although there are many types of linear actuators available, selecting the right one for your application is crucial. When purchasing an actuator, it's important to understand the specific requirements of your situation. Below are some key considerations to help you choose the most suitable actuator for your needs. When evaluating where the actuator will be installed, it's crucial to determine the type of motion required. For instance, the motion needed to open and close a door or valve differs from that required to activate a process on a machine. Actuators are designed to produce either straight-line or circular motion. Assessing the type of motion and how it integrates into your process is essential for selecting the right actuator. Electrical actuators have been refined and optimized for a wide range of applications, making them the most popular and commonly used type. However, they may not be suitable for all conditions. In cases where power is limited or unavailable, it may be necessary to consider pneumatic or hydraulic actuators as alternatives. An actuator designed for use in outer space, where precision and accuracy are paramount, may not be suitable for heavy-duty applications in a factory setting. The choice of actuator often depends on the size and nature of the work. Small, delicate operations require actuators capable of precise movements, whereas tasks such as stacking pallets or managing a valve may not demand the same level of precision. A primary function of an actuator is to deliver force to perform work, such as lifting, tilting, moving, activating, and sliding objects and materials. The extent of work an actuator can perform depends on the force required to move a load, which is defined by its load capacity. Manufacturers provide detailed information on their products' load capacities, and this data should be carefully reviewed to ensure that the actuator meets the requirements of the job. Actuators are available with various motors and stroke lengths. The stroke length is determined by the length of the shaft or lead screw. Before purchasing an actuator, it is important to assess the required amount of movement for the job to ensure the actuator meets those needs. While speed is an important factor when selecting an actuator, it is also crucial to consider the weight that needs to be moved. When a substantial amount of force is required, the actuator will move more slowly. Speed is typically measured in distance per second. Calculating the necessary duty cycle can provide valuable data to help choose an actuator with the appropriate speed and performance to meet the work conditions. Most actuators do not perform well in dirty, wet, moist, or dusty environments. While some models are designed to work underwater, most require protection in the form of enclosures or shelters to function effectively in unclean, rugged, or rough conditions. Each actuator features a distinct mounting style. For example, a dual pivoting mount positions the actuator on either side of the mounting point, allowing it to pivot. In contrast, a stationary mount enables the actuator to produce push or pull motions from a fixed position. Proper mounting is crucial for ensuring optimal performance and efficiency, and it should be carefully considered during the purchasing process. Side loading occurs when force is applied radially to the actuator, which can lead to issues such as offset loads, inadequate fixed mounting, or loads pushing against the actuator. Problems associated with side loading include extension tubes pushing against the cover, rough ball nut operation, damage to gears, and actuator binding. If the space where an actuator is needed seems restrictive and confined, you might worry that an actuator wont fit due to its size or length. However, there are actuators specifically designed for such conditions. Several manufacturers offer various types of telescoping actuators that are built to operate effectively in compact spaces. Pin-to-pin mounting, with spherical bearings on both sides, provides maximum tolerance for misalignment. Higher-quality designs often include features that restrict roll around the actuation axis by limiting one of the spherical bearings to only two degrees of freedom, enhancing stability and precision. Using spherical bearings on both sides allows for maximum tolerance of misalignment. Higher-quality designs often feature constraints that limit roll around the actuation axis by restricting one of the spherical bearings to only two degrees of freedom. Chapter Eight - Benefits of Linear Actuators The use of actuators began immediately after World War II, initially involving motors to create rotary motion, which was then converted into linear motion using ball screws. The modern version of linear actuators was introduced in the 1980s, featuring high-strength samarium and neodymium magnets. Todays models include coils that work with these magnets to move the assembly. Each year, new and innovative methods for utilizing linear actuators continue to emerge. These advancements enable the automation of industrial machines, provide precise control, and facilitate the positioning of heavy loads. The applications of linear actuators are vast and continually expanding. Linear Actuator Benefits Actuator Safety Linear actuators offer a safer alternative compared to other energy conversion methods. They stand out for their effectiveness, boasting a high success rate while minimizing risk to people, machines, and products. In contrast, other processes often demand more time, are less efficient, and carry higher risks. By utilizing a linear actuator, machines can operate autonomously with reduced risk of interference or danger. Linear Actuator Cost When evaluating the use of linear actuators, a key consideration is their return on investment. Although the initial cost may be higher than other methods, the long-term benefits and efficiency make linear actuators a superior choice. Their straightforward design and durability ensure they deliver exceptional value over time, making them a worthwhile investment. Actuator Installation Linear actuators are compact and straightforward, making their installation both quick and easy. With just a few wire and cable connections, they can be set up and ready for use with minimal effort, delivering impressive accuracy right away. Lack of Noise Most linear actuators operate quietly, with the amount of noise they generate largely dependent on their quality and usage. Key factors influencing noise levels include the manufacturer's standards and the quality of materials used. Generally, linear actuators produce noise levels of less than 55 decibels (dB). Actuator Durability A linear actuator can perform over 200 million cycles before requiring replacement. Throughout this extensive lifespan, it typically needs no repairs, adjustments, or maintenance, consistently delivering exceptional accuracy and efficiency. Conclusion Linear actuators convert rotational motion into push or pull linear motion, which can be used for lifting, dropping, sliding, or tilting machines or materials. Though the function of all linear actuators is the same, there are several different ways the motion is achieved. The basis for a linear actuators design is an inclined plane. Linear actuators come in several configurations to fit any possible application, environment, setting, or industry. Modern linear actuators look much the same as they did when they were first introduced. Static and dynamic are the two load capacity variables of a linear actuator. Your browser does not support the video tag.

What is a linear actuator simple. What is an example of a linear actuator. What is a linear actuator and how does it work. What is a hydraulic linear actuator. What is a pneumatic linear actuator. What is a mechanical linear actuator. What is a linear actuator used for. What is a duty cycle in a linear actuator. What is the purpose of a linear actuator. What is a electric linear actuator. What is a linear resonant actuator. What is a piezoelectric linear actuator. What is a linear actuator motor. What is the stroke of a linear actuator. What is a reciprocating linear actuator.