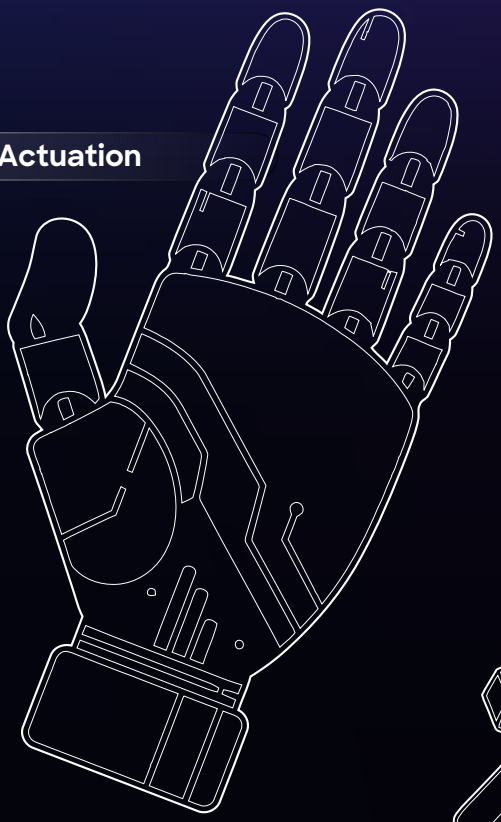
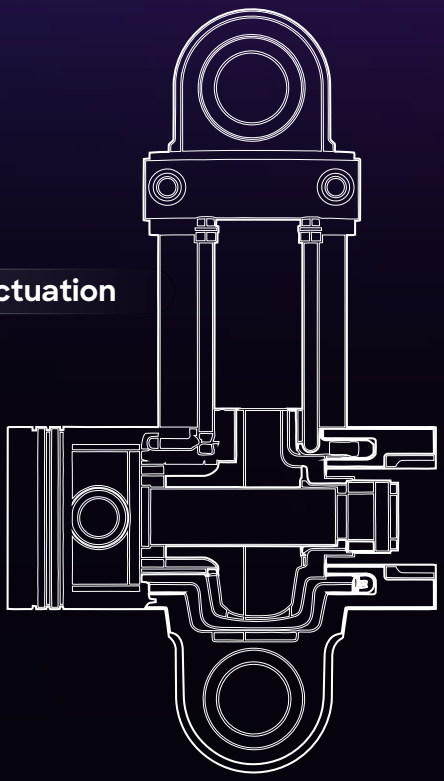
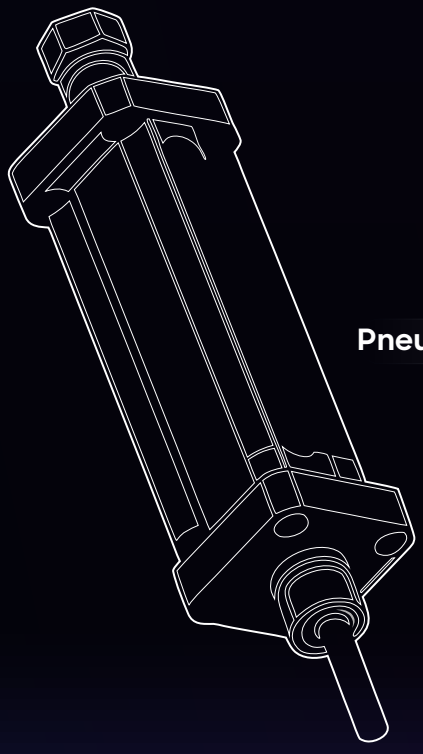
Selecting the Right Actuation Method

Electric Actuation



Hydraulic Actuation





Pneumatic Actuation

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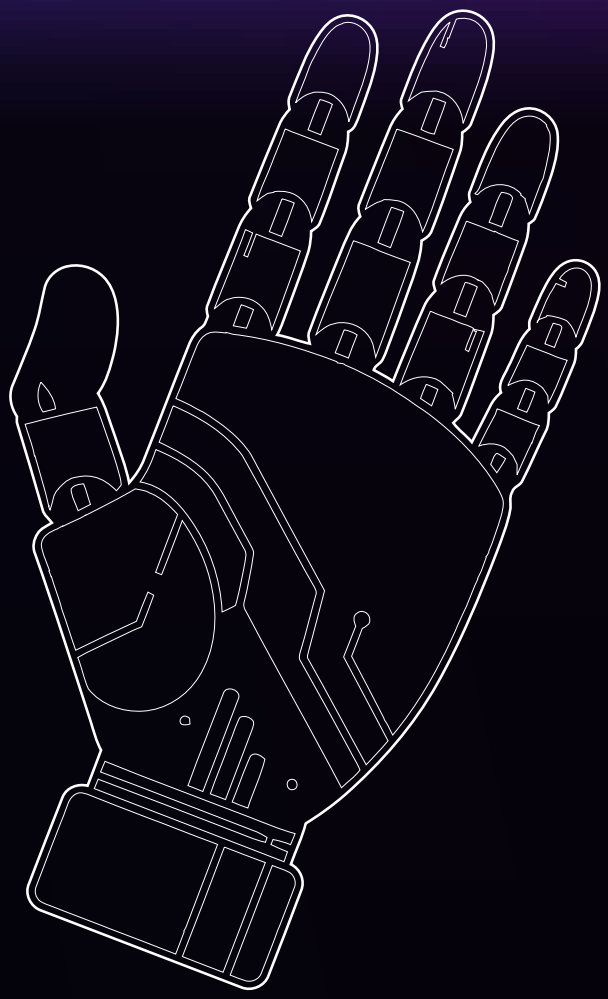
Electric Actuation



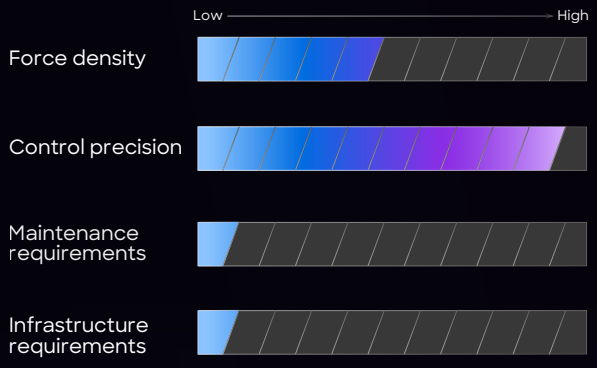
Electric actuation uses electrical power to create motion through motors. It is usually the best option when precision, control, and repeatability are the priority. It is attractive when electrical power is already available elsewhere in the system, since it can be integrated directly through wiring rather than requiring pumps, compressors, or fluid lines. Due to its favourable strength-to-weight ratio, electric actuation can also be attractive in weight-conscious applications such as mobile robots.

Electric actuation is generally cleaner and lower-maintenance than fluid-based systems. There are no hoses, seals, or working fluids to manage, and no risk of leakage, which makes it appealing in environments where contamination is a concern. It is also typically the most energy-efficient option, especially in mobile or battery-powered systems.

It can be a strong fit for applications with frequent, repeatable motion, although duty cycle still depends on the application. If the system needs to operate continuously under heavy load, electric actuation may be less advantageous than hydraulics. In that sense, electric actuation trades maximum force density for greater precision, cleaner operation, lower maintenance, and easier integration.

BEST WHEN

- ✓ Precise motion or positioning matters
- ✓ The system already has electrical power and controls
- ✓ Weight is an important system constraint
- ✓ Lower-maintenance operation is a priority



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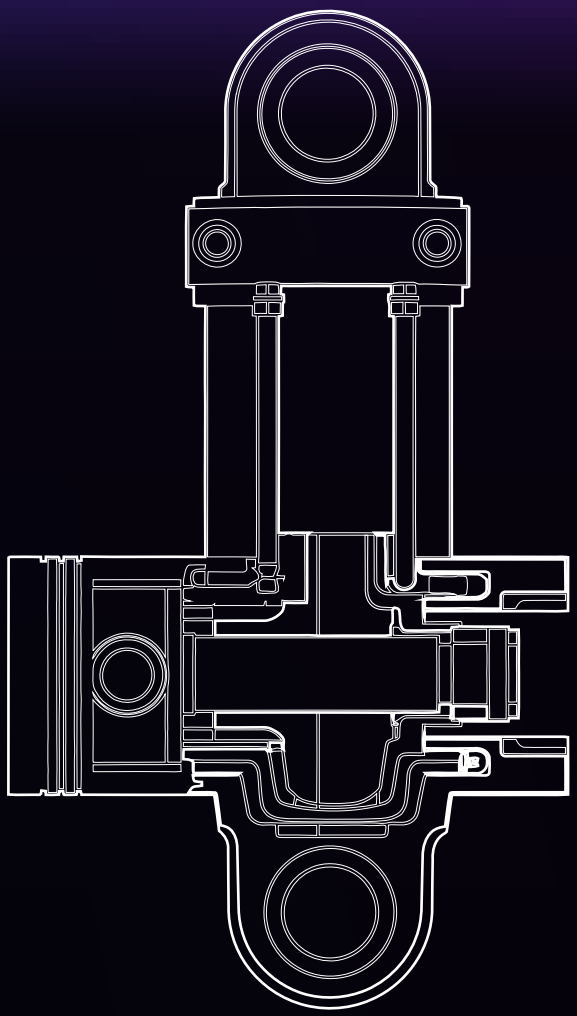
Hydraulic Actuation



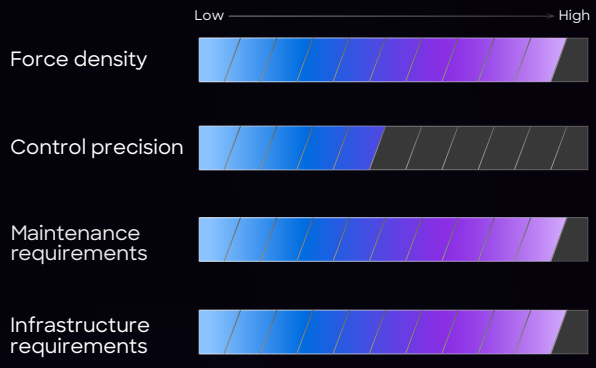
Hydraulic actuation uses pressurized fluid to generate motion through cylinders or hydraulic motors. While it can provide solid control, its main advantage is force density. Hydraulic systems can deliver high output from a relatively compact actuator, making them a strong option for heavy, load-bearing applications. They can also work well in systems that cycle frequently over long periods.

That said, hydraulic actuation does come with added system complexity. It depends on pumps, reservoirs, hoses, and seals, so it usually makes the most sense when hydraulic power already exists elsewhere in the system or when the force requirement is high enough to justify that infrastructure.

Hydraulic systems also require more maintenance over time, with fluid handling, seal wear, and leaks becoming part of the tradeoff. While these demands are often acceptable in rugged, heavy-duty environments, they can make hydraulics less attractive in applications requiring clean operation. Therefore, hydraulic actuation is typically chosen when very high force in a compact package outweighs the benefits of cleaner operation, lower maintenance, and simpler supporting infrastructure.

BEST WHEN

- ✓ High force must be delivered in a compact package
- ✓ The system involves heavy, load-bearing work
- ✓ Hydraulic infrastructure already exists or is justified



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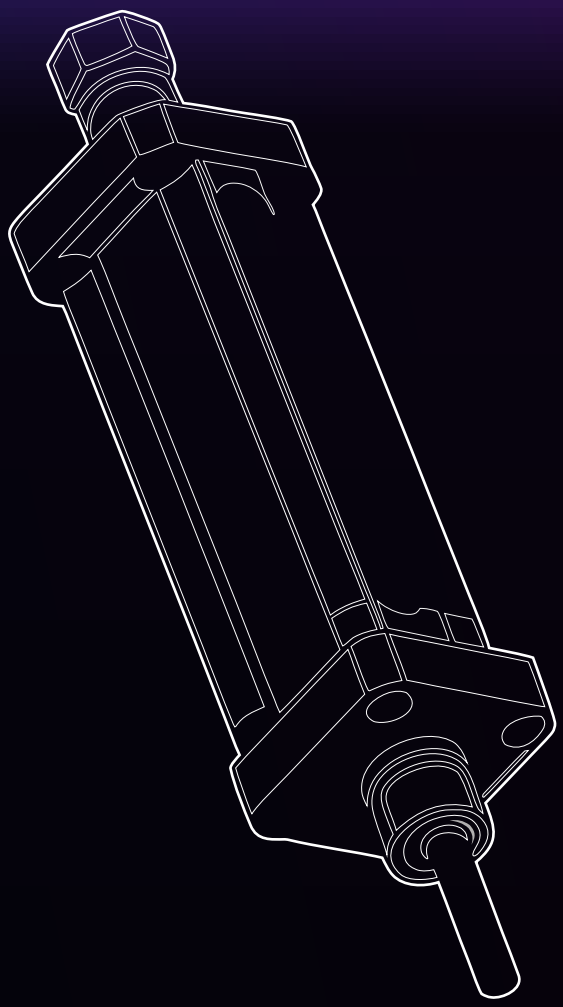
Pneumatic Actuation



Pneumatic actuation uses compressed air to create motion through linear or rotary actuators. It is commonly used for simple, fast, repetitive movement in fixed industrial settings. It makes the most sense when compressed air is already available, since that lowers the barrier to adding actuation.

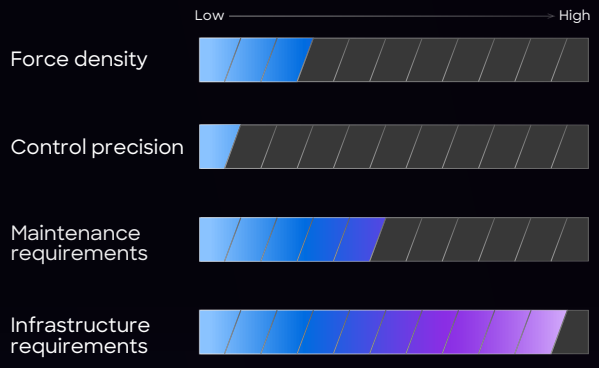
Pneumatic actuators are either engaged or disengaged, moving between preset positions rather than providing continuous position control. This makes them well suited to simple, repeatable motion, but less suitable for applications requiring precise positioning. Pneumatics also offer lower force density than hydraulics, making hydraulics the stronger choice when very high force in a compact package is the primary requirement.

Like hydraulics, pneumatics require dedicated supporting infrastructure, including compressors, valves, fittings, and air lines. Maintenance demands are usually lower than with hydraulics, but still present. Pneumatic actuation is also the least energy-efficient of the three actuation methods, because energy is lost in compressing and distributing air as well as through leaks and pressure drops. Environmental suitability depends on the application, since moisture, air quality, and temperature can affect system performance.

To sum up, pneumatic actuation is often chosen when fast, simple, repeatable motion matters more than precise positioning, maximum force density, or energy efficiency.

BEST WHEN

- ✓ Motion is simple, fast, and repetitive
- ✓ Compressed air is already available
- ✓ Cost, simplicity, or flexibility matter more than precis control



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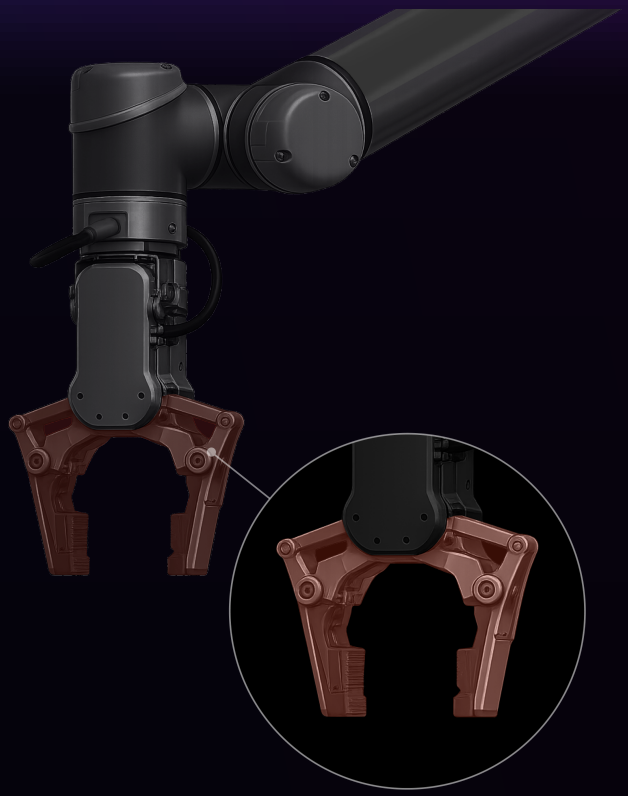
Cobot end effectors

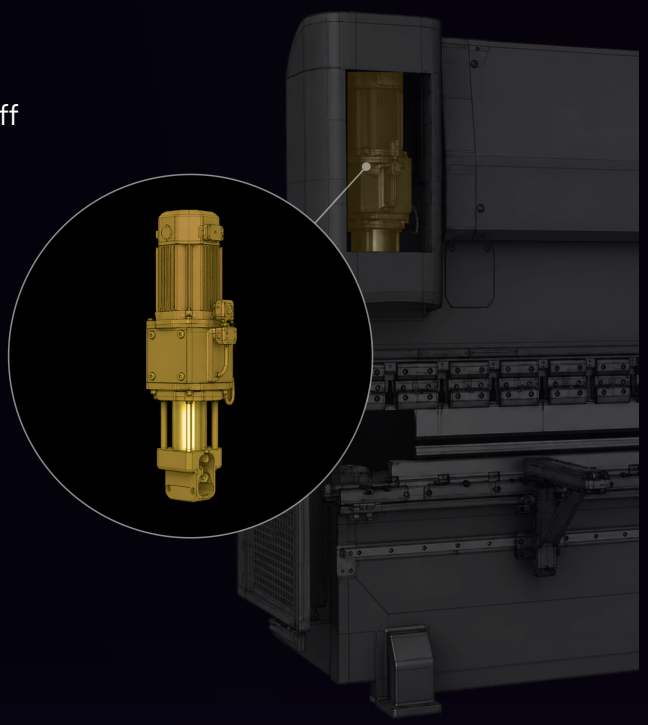
A cobot end effector, such as a robot gripper used to pick up and place parts, is a good example of how actuator choice has shifted over time. In the past, pneumatic grippers were widely used because they were lower in cost, relatively simple to design, and able to deliver the needed gripping force when electric options were still bulkier, more expensive, and more limited in output. In fixed industrial settings, they also benefited from existing compressed air infrastructure, which made them easy to implement.



That has shifted with the development of higher-torque motors and linear electric actuators. For many light- to medium-duty gripper applications, electric actuation now offers sufficient force along with lower maintenance, easier routing through wiring rather than air lines, and better energy efficiency. Pneumatic grippers remain common for heavier payloads, particularly where compressed air is already available. That air supply can also support related functions such as generating vacuum or moving parts with short air bursts.

Press brakes

A press brake used to bend sheet metal illustrates the tradeoff between hydraulic and pneumatic actuation. Both can be used to perform similar bending operations, but the better choice depends on the force required, the size of the machine, and the needs of the application.



Pneumatic press brakes are generally better suited to lighter-duty applications where lower cost and simpler operation are priorities. Hydraulic press brakes make sense when significantly more force is needed. In some high-force applications, hydraulics may also be the safer choice, because using very high-pressure compressed air can introduce additional risk.

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