White Paper

THOMSON
Linear Motion. Optimized.™

Why Electric Actuators are Increasingly Replacing Hydraulic Systems

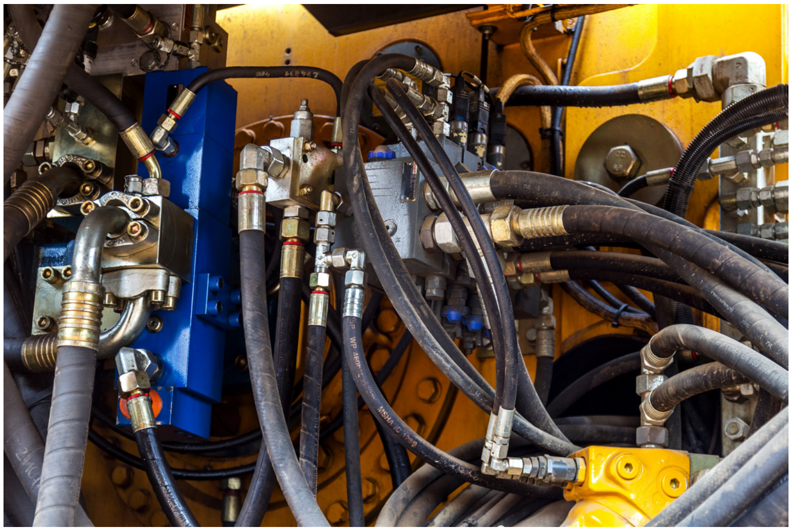
Executive Summary

Hydraulics have traditionally provided much of the muscle for the industrial revolution, but that functionality has come with a cost. Hydraulic systems are complicated and messy, labor and space-consuming, and expensive to operate and maintain. For many years, these systems have been the only option for several applications. Today, however, advanced electromechanical linear actuators offer a high-power, zero maintenance solution that is simpler, cleaner and more controllable than its hydraulic counterparts. If you typically specify hydraulic cylinders for your machine designs, here are some good reasons to consider electromechanical alternatives.

Hydraulic Systems Can Be Complicated

In a hydraulic system, barely compressible hydraulic fluid amplifies electrical energy to move a load. In a typical dual-action system, an electric motor drives a pump, which delivers the incompressible hydraulic oil to a cylinder containing a tightly sealed, but easily movable piston attached to a piston rod. As the intake fluid arrives from the reservoir, it exerts pressure on the piston rod, which moves the load movement. As the piston moves, it forces fluid out the other end of the cylinder to the reservoir for eventual return to the chamber.

Supporting this complex process requires an external system of hoses, connectors, filters, switches, valves and pumps that cycle the fluid to and from the cylinder, enabling movement. This is repeated for every axis of motion. Even the smallest system would require at least eight separate moving components, which introduces a higher than average risk of system failure. Maintaining consistent pressure is critical, and that depends on proper valve settings, connections and switching.



In contrast to electromechanical actuators, hydraulic systems are complicated due to the requirement of hoses, connectors, valves, filters and switches to operate.

As oil is pumped through the system, filters may clog, oil levels may drop; bearings, seals and gears may deteriorate; all of which can contribute to leakage, noise and other problems. Numerous other problems in hydraulic systems, such as valves not opening or closing properly, changes in oil viscosity, and oil overheating, are present and addressable but jeopardize reliability. In addition to the effort taken to synchronize and maximize performance of so many moving parts, hydraulic cylinders consume valuable space, which is increasingly important as systems – both mobile and stationery – are becoming smaller and smaller. Noise is an issue as well. Even with the system operating at peak performance, motors, pumps and other components provide a steady serving of distracting noise. To reduce the noise, some users are resorting to noise mitigation products and services, which add even more design challenges and costs.[1]

In addition to noise, the requirement to have hydraulic systems idling in wait makes them inefficient consumers of energy, which increases operating costs. This is especially true when the system must hold a static load in place, as can be the case for mobile equipment.[2]

Most applications involve multiple hydraulic cylinders. The more cylinders in use, the greater the complexity, ambient noise, energy consumption and related costs.

Hydraulic Systems Can Be Messy and Potentially Dangerous

While the complexity of hydraulic systems can get expensive in terms of space utilization, noise mitigation and energy consumption, there is an additional layer of maintenance related to the characteristics of hydraulic fluid itself. There are several different types of fluid used, but all require special handling because they are potentially grimy, smelly, slippery and hazardous. The following are some of the potential hydraulic fluid handling issues that have been identified:

Toxicity. The U.S Agency for Toxic Substances and Disease Registry reports that some types of hydraulic fluids can irritate skin or eyes and that ingesting certain types can cause pneumonia, intestinal bleeding or death in humans. It also says that swallowing or inhaling certain types of hydraulic fluids has caused nerve damage in animals.[3]

The effects of breathing air with high levels of hydraulic fluids are not known, but some countries have set hydraulic fluid exposure limits. For example, the U.S. Occupational Safety and Health Administration (OSHA) has set an exposure limit of 2,000 milligrams per cubic meter (mg/m^3) of petroleum distillates for an 8-hour workday and 40-hour workweek.[4] The National Institute for Occupational Safety and Health (NIOSH) recommends an even stricter exposure limit of 350 mg/m^3 of petroleum distillates for a 10-hour workday and 40-hour workweek.

Contamination. In addition to being potentially toxic to humans, hydraulic fluids can be harmful to the environment. The U.S. Environmental Protection Agency (EPA), for example, includes hydraulic fluids on its list of oils that require special handling.

Slip and fall. Fluid leaking from systems or spilled during maintenance can present slip and fall hazards. There are many reported cases of workers who have been injured by slipping on puddles of leaked fluid or falling while climbing up onto their machines with oil on their hands or shoes.[5]

Burn hazards. During routine operation, hydraulic systems can reach as high as 180 degrees Fahrenheit, but some can go significantly higher than that, reaching temperatures that can cause severe skin burns, while also heating metal components to dangerous levels.[6]

Cleanup. Indoor spills may also be subject to local regulation or require additional investment in absorbent substances or other cleanup services.[7]

Combustibility. Petroleum-based hydraulic fluids are less flammable than petroleum middle distillate fuels such as jet fuel, kerosene or diesel fuel. These can be a fire hazard if sprayed, as might happen when high-pressure leaks convert the fluid to an aerosol state.[8]

Hydraulic systems use various types of fluid that can be messy, slippery and hazardous to humans and the environment. As hydraulic fluids lose effectiveness over time, special care and regular maintenance is critical.

Because of these factors, hydraulic fluid requires special care during storage and fluid changes. Because hydraulic fluids degrade and lose effectiveness over time, they must be replaced regularly, which requires maintaining an inventory, adding costs and presenting additional potential for spillage. This also means that someone must coordinate the checking of filters and oil integrity to determine when to change the fluids.[9]

Hydraulic Systems Have Limited Control Capability

Everything we have said thus far relates to conventional use of hydraulics, but if you want to integrate them into any kind of system optimization or modernization strategy, the complexity of the required infrastructure compounds the situation and adds costs. Because hydraulic cylinders are designed only for simple end-to-end movements, instructing one to stop at a certain position, change location, or attain a specified speed requires adding control components.

Likewise, ramping the speed up, slowing it down or following a consistent motion profile would require external components, which can be expensive to integrate, operate and maintain. Obtaining accurate position readings, for example, would require an external measuring device such as a rotary encoder. Speed control would require sophisticated valve assemblies.

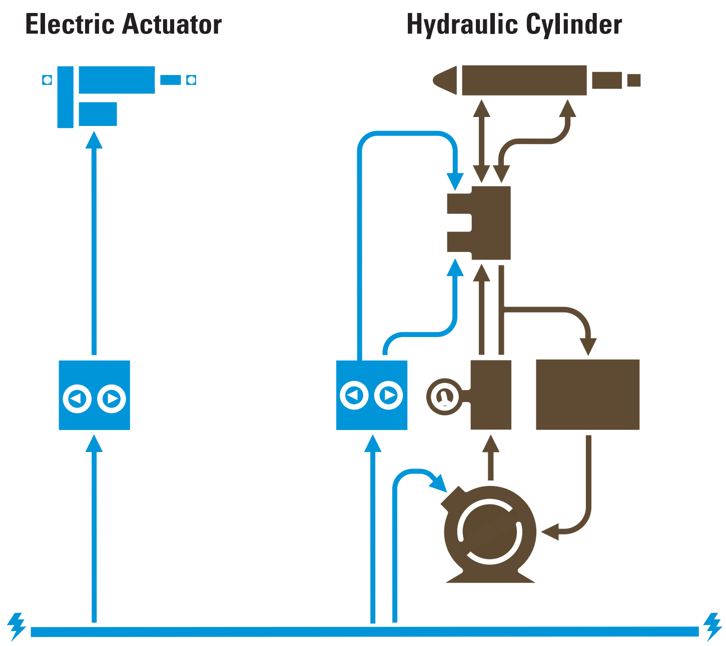


Figure 1: Detailed illustration comparing electric actuators and hydraulic systems.

Figure 1 compares simple ways to run electric and hydraulic cylinders back and forth. Electric actuators are simpler and more compact in design, ensuring no contamination risks. Hydraulic cylinders, on the other hand, are more complex, requiring external support infrastructure as well as more space-demanding solutions that add more weight to the complete system.

Electromechanical Actuators Deliver Comparable Performance Without the Drawbacks

Given their high operating, maintenance and cleanup costs; safety risks; inefficient energy consumption; and minimal control capability; hydraulic systems are much less suitable for the new generation of intelligent linear machines than electromechanical actuators.

Electromechanical linear actuators have advanced to provide the high-load, compact advantages of hydraulics but without the

Comparing Electromechanical Actuators and Hydraulic Systems

	Electromechanical	Hydraulic
Footprint/ Installation	All functionality built in; mounts with just a few bolts	Requires external support infrastructure, pumps, valves, etc.
Cleanliness/ Safety	Zero environmental contamination or leakage; compact design is leaner to manufacture	Fluid leakage and spill issues; numerous sub-components have high resource requirements; potential hazard[10]
Maintenance	Negligible; programmable end-of-stroke limits extend life	Pumps, valves and hoses require attention; components may have to be resized or changed out; fluid must be replaced, and leaks repaired
Noise	Silent while both idle and moving loads	Higher noise levels due to pumps, air pressure or fluids, in both operation and during
Control	Multiple digital and analog options; low-voltage switching; pulse-width modulation	Minimal capability requires even more external instrumentation
Static Load Handling	Hold power with off; no drift	Requires pump, but drift still high
Cost	Longer component life, high redundancy, battery operation, and low energy consumption reduces cost	Energy inefficient; draws power whether in use or not

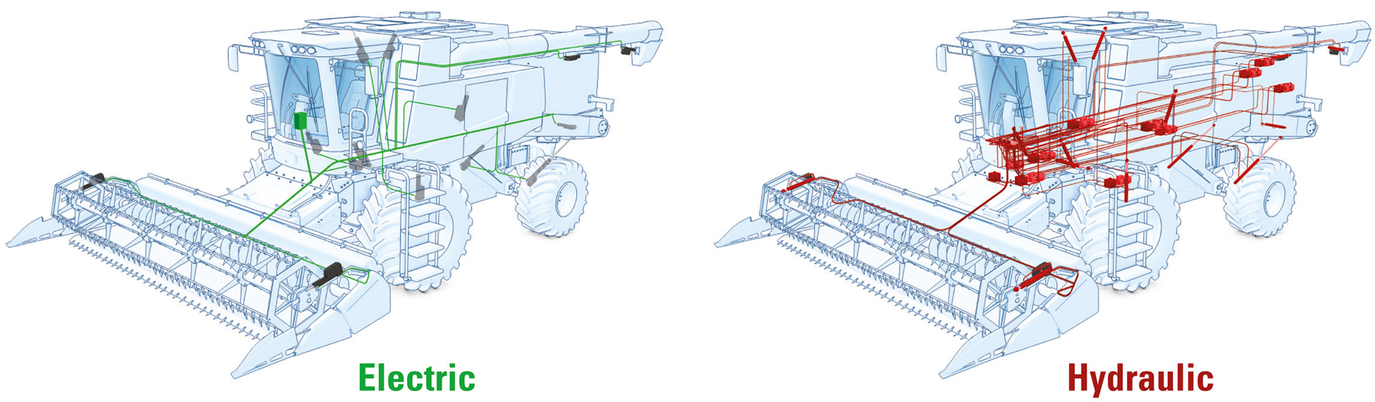


Figure 2. Hydraulic and electromechanical wiring comparison.

drawbacks. Today's electromechanical actuators can handle loads of 16 kN or more without need for messy oils and complex hoses, valves, pumps and other assemblies.

In electromechanical actuators, all functionality can be embedded in the actuator housing itself, which connects an electronic control unit (ECU) with only a few wires. (Figure 2) Leveraging this capability are built-in microprocessors that can be programmed to report position, provide diagnostic feedback that improves performance, and handle complex functions like synchronizing multiple actuators.

Electromechanical actuators can accept commands and, in return, provide status information such as position and speed, and safety-related data such as load or temperature. And because functionality can be switched on instantly, there is no noisy, costly system idling.

Considering all these factors, electromechanical actuators are increasingly being specified for the next generation of mobile equipment, industrial machinery, aerospace systems and many other applications where simple, powerful and smart linear motion is required.

Thomson Industries, Inc. offers a full selection of smart electromechanical linear actuators to match the requirements of various applications. Visit www.thomsonlinear.com/smart for details.

References

[1] Brendan Casey (2019), Symptoms of Common Hydraulic Problems and their Root causes. Retrieved from: https://www.machinerylubrication.com/Read/531/hydraulic-root-causes

[2] Milos Vukovic, Hubertus Murrenhoff (2015) The Next Generation of fluid power systems. Retrieved at: https://www.researchgate.net/publication/283085606_Mobile_Working_Hydraulic_System_Dynamics

[3] Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, Public Health Service in Atlanta, GA. Toxicological Profile for Hydraulic Fluids (1997) Retrieved at: https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=756&tid=141

[4] United States Department of Labor, Occupational Safety and Health Administration. Air contaminants. Retrieved at: https://www.osha.gov/laws-regs/regulations/standardnumber/1915/1915.1000

[5] Joseph Hrinik (2007) Hydraulic Fluid Hazards. Retrieved at: https://www.forkliftaction.com/news/newsdisplay.aspx?nwid=4584

[6] J. Eric Freimuth (2017) Did you know that hydraulic fluids can kill? Retrieved at: https://www.linkedin.com/pulse/did-you-know-hydraulic-fluids-can-kill-j-eric-freimuth/

[7] Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, Public Health Service in Atlanta, GA. Toxicological Profile for Hydraulic Fluids (1997) Retrieved at: https://www.atsdr.cdc.gov/toxfaqs/tfacts99.pdf

[8] George W. Mushrush, Heather D. Willauer, Jean L. Bailey, John B. Hoover & Frederick W. Williams (2006) Petroleum-Based Hydraulic Fluids and Flammability, Petroleum Science and Technology, 24:12, 1441-1446, Retrieved at: https://www.tandfonline.com/doi/abs/10.1081/LFT-200056782

[9] W.D. Phillips (2006) The High-Temperature degradation of hydraulic oils and fluids. Retrieved at: https://www.hyprofiltration.com/clientuploads/directory/Knowledge/PDFs/High%20Temp%20Degradation%20of%20Hydraulic%20Oils%20%20Fluids.pdf

[10] Yao, Z., Tang, J., Rui, T., & Duan, J. (2017). A time–frequency analysis based internal leakage detection method for hydraulic actuators. Advances in Mechanical Engineering. Retrieved at: https://doi.org/10.1177/1687814016685058