Electric Linear Actuators, Hydraulic Systems & Manual Operation:
Important Criteria for Selecting Suitable Motion Technologies for OEM Applications

This whitepaper explains key considerations that impact the selection of motion devices for OEM designs. The suitability of electric linear actuators, hydraulics systems, and manual operation overlaps in many applications. Understanding key considerations aids engineers in the selection of the most appropriate solution.
# Table of Contents

**Section One:**
Basic Guidelines for Selection of a Motion Solution ........................................ 3

**Section Two:**
Basic Specification ........................................... 5

**Section Three:**
Performance Requirements ................................ 7

**Section Four:**
Controlling the Application .................................. 10

**Section Five:**
Standards and Safety ......................................... 11

**Section Six:**
Economic Considerations .................................. 13

**Section Seven:**
Conclusion ..................................................... 14
Section One: Basic Guidelines for Selection of a Motion Solution

Recent advances in motion technology provide design engineers a wide array of options to meet their needs for movement. However, these developments have also complicated the selection process for determining the most appropriate solution. This whitepaper is designed to aid OEM design engineers in the selection of the most appropriate technology for a given application.

Electric actuators are linear designs that incorporate a motor, rotary-to-linear mechanical converter, power regulation, and controls in one self-contained unit. Electric actuators are becoming more prevalent in OEM designs traditionally associated with fluid power and even manual mechanisms.

This planter is a typical application for LINAK® electric actuators, which provide movement to simplify rugged designs for both manufacturers and end users. Here, the actuators (under command of controls) intelligently adjust the hatch opening to ensure that the right amount of seed is released.

LINAK TECHLINE® actuation is also found in harvesters, ventilation applications, lawn mowers, adjustable workstations, and a myriad of industrial applications.
Section One: Basic Guidelines for Selection of a Motion Solution

Before discussing specific selection criteria, several central guidelines can help narrow the focus to suitable technologies:

Applications requiring the movement of 3,000 lb or greater preclude most electric and manual options, so hydraulic systems may be the most appropriate solution. One exception is applications in which multiple electric actuators can be used in tandem.

Where loads are less than 200 lb; where precision has no bearing on overall system performance and where the design’s cost structure cannot accommodate the higher cost of a hydraulic or electric solution, manual operation is the clear choice for actuation.

In applications requiring movement of 200 to 3,000-lb loads, both electric and hydraulic solutions are viable. Here, consideration of less sweeping guidelines is required to identify the most suitable technology.
Section Two: Basic Specification

Basic considerations for OEM motion applications include loads, speeds and travel (or stroke) lengths.

Loads
The load that must be moved in an application is a key factor in determining the most appropriate motion solution. As mentioned, load is one central specification that immediately disqualifies certain solutions. The units of measure for load — defined here as the force interacting with the motion device — are pounds (lb) and Newtons (N).

Consider an application in which a part weighing 500 lb must be moved. Depending on the mechanical advantage or disadvantage of the design, the load experienced by the electric actuator, hydraulic cylinder or operator can actually exceed or be less than the weight of the parts. It is this load interacting with the motion device that must be factored into the design.

Myriad load types exist. One is peak (or maximum) dynamic load — the largest load experienced while the application is in motion. Another is peak (or maximum) static load — the largest load experienced while the mechanism is stationary. Static load ratings are important to consider when determining whether a mechanism will retain its position when subject to outside forces such as shock and vibration.

Consideration should also be given to any side-loading forces — those loads acting perpendicular to the motion device. Machinery must be designed to support these forces, or serious damage can occur. Typically the risk of damage is greatest when an electric actuator or hydraulic cylinder is in an extended position.

Many times, the dynamic load of an application will change as the motion device moves. Here, it’s useful to record these changes as load over the travel of the motion device. Called mapping the load curve, this task can be executed with an appropriately designed load cell and oscilloscope.

Finally, consideration should be given to whether the load creates a compression or tension force on the motion device. In fact, some installations subject the motion device to both compression and tension as the unit travels through its range of motion.
Travel or Stroke

Typically, the amount of travel required by the application is defined as the stroke length of a motion device. Maximum stroke length is limited by how the device is designed and the load experienced by the actuator, especially in the extended position.

For example, an electric actuator or hydraulic cylinder may move a dynamic load to 10,000 N over 1,000 mm of stroke with no problems — if it experiences the highest load when the device is in the retracted position, and load is significantly lower when the device is extended. However, the reverse may be unacceptable due to the potential of damage.

Power source

The power source (if any is available) should also be considered during the evaluation process. Obviously, electric actuators and most hydraulic systems require some type of electrical power source to operate, but their voltage and current requirements vary. The designer should ask: Is the supply voltage 12 V, 24 V or another value? Is the voltage stable or variable? AC or DC? What is the frequency? Also, actual voltage near the usage point (typically at a motor) must be ascertained since there is a potential for a voltage drop over the distance between the power source and usage point.

Finally, current draw must also be considered to determine that it is appropriate for the system design. Current required by an electric actuator or hydraulic system helps determine the power supply, wiring gauge and method of controlling and activating the motion device.
Section Three: Performance Requirements

Assuming that a motion device can meet an application’s basic requirements for moving a certain load over the required length of travel, the next consideration is performance. Included are some of the most important considerations regarding actual device performance. This is not an all-inclusive list so further examination of the requirements of the application is required.

**Speed**

Speed is typically measured in inches per second or millimeters per second. Often, motion device speed has an inverse relationship to the load at any given point in time — so the higher the load, the slower the speed at a given point in travel. As mentioned, because load on a motion device may change while the application is moving so will its speed. Therefore, it may be more valid to calculate the time required to perform a certain function (in other words, one full cycle) than the nominal speed rating at a given load.

To illustrate, assume that an application requires the movement of 1,000 N over 50 mm in one second. A motion device that has a speed rating of 50 mm per second at 1,000 N may not be the best solution if the load changes greatly over the length of travel. Instead, the optimal design for this application is rated for the average load and subsequent average speed required to travel the 50 mm in the time required.

The LA36 LINAK actuator is designed specifically for applications in harsh environments. Features include max load rating of 10,000 N and an integrated clutch.
Environmental conditions

Consideration should be given to the environmental conditions experienced by the application — including (but not limited to) temperature, moisture, dust and exposure to corrosive substances.

Varying temperatures, particularly in outdoor applications, can significantly impact motion system performance. For example, cold temperatures can increase the viscosity of hydraulic fluids and grease, alter subcomponent dimensions, change the properties of elastomers used for seals and more. Oftentimes, performance specifications such as load ratings, speed and current are limited to a specific temperature range. A design operated at temperatures below or above its rated range yields unpredictable output. For example, current draw may significantly increase in low temperatures due to increased internal friction caused by higher grease viscosity, or dimensional changes of essential subcomponents.

Where motion devices may be exposed to dust or moisture, ratings such as IP (ingress protection) should be considered, in this case IP65. Here, the first number designates the level of protection from ingress of dust particulates and the second number indicates the design’s protection against moisture ingress. IP ratings and their explanations can be found on the Internet.
In certain applications, designs may require industry-specific certification — particularly those engineered for use in applications that may be exposed to explosive gas or dust. Exposure to corrosive environments necessitates specialized components. In the same way, exposure to salts, fertilizers, pollution (such as sulfur dioxide), moisture and other corrosive materials requires a solution that can sufficiently withstand corrosion. Failure to do so significantly reduces the length of a motion design’s life.

**Ruggedness**
Consideration should be given to the ruggedness required by the application. For example, two motion control solutions may be rated to the same maximum dynamic loads, but when exposed to significant shock loading, the weaker of the two solutions may be damaged. Here, the design intent of the motion device should be examined. Typically, a designer should review vibration, shock load and other test results, as well as a potential technology’s success in past applications that resemble the one at hand.

**Duty cycles**
Duty cycle is the amount of time a motion control device operates relative to the amount of time it is idle. Therefore, the maximum duty cycle rating indicates the maximum amount of time a given device can effectively operate before it requires a period of inactivity. The value increases if the device is not loaded at its maximum rating; it is decreased if the device must operate in extreme temperatures.

**Noise level**
In working environments that require noise minimization, the amount of sound produced by the motion device should be considered and quiet-running components chosen.

**Product lifetime**
The length of time that a product is expected to operate before being replaced should also be determined. Chosen system life should ultimately account for the effects of downtime and repair costs associated with failure.

For years, Case (the construction division of CNH) has used LINAK actuators to operate engine hoods on their mid-size wheel loaders. The actuators are used for their strength, reliability and resistance to environmental conditions. More recently, new generations of wheel loaders are being designed to incorporate an even more rugged LA36 for engine hood lifts. An additional factor here is the presence of LINAK subsidiaries in the U.S., Italy and Brazil, where wheel loaders are manufactured.
Applications incorporating motion require some method for controlling the movement. Here, the nature of operator-device interactions is a key consideration.

Motion controls abound — from simple solutions for manual movement, to double-pole, double-throw (DPDT) switches, to highly sophisticated controllers. The full suite of motion control options is not explained in this whitepaper. Instead, we outline key considerations — including budget constraints, safety and coordination with other devices — that establish the most appropriate control technology for common OEM applications.

Some applications require positioning feedback from motion controls — to allow the operator or system to precisely track movements or command the device through paths and positions. The information can be used to coordinate multiple axes or ensure design safety.

Myriad positioning feedback types exist, but all are either absolute or relative. Absolute positioning tracks device position along a known trajectory and feeds that information to the controller. For example, a potentiometer typically tracks fixed linear trajectories and outputs the collected information as analog signals to the controller. In contrast, relative positioning — as that executed by Hall effect sensors — typically sends digital (pulse) signals back to the controller anytime the motion device moves, thus requiring initialization to a home position before operation.

Other control considerations include the positioning feedback’s accuracy and repeatability, and whether it should be embedded in the motion control device.
Section Five: Standards and Safety

Some applications must meet safety standards and industry certifications. These requirements depend on the application, the country in which the application will be used, and other considerations. For example, some applications may require evaluation and approval from groups such as Underwriters Laboratory (UL), CSA, ETL and CE.

In regards to functional safety, factors requiring evaluation are the effective protection of the operator and other personnel, as well as the application itself.

Different applications emphasize different aspects of safety but the following are most common:

- **Ergonomics** – Is the application designed to protect the operator from injury during operation? Injuries can be sustained both when the application is functioning properly and when the application has failed in some manner. Could the application injure someone in a one-time incident, as in a back injury from lifting a heavy load? Could the application injure someone as a result of frequent, repetitive motions over a longer period of time?

- **Failure modes** – The design should eliminate or mitigate the risk of damage and safety breaches resulting from application or motion device failure. Another consideration is the replacement procedure for various actuator positions, should the motion device happen to fail at each failure mode.

- **Environmental issues** – Issues related to environmental effects of the application should be considered — including when the motion control device is working properly and in case of failure (as when a hydraulic design leaks).

- **Other foreseeable risks** – Designers should assess reasonably foreseen dangers resulting from both proper and improper use of the design. Once potential safety risks and hazards are identified, they should be averted with preventive design features.

Traditional manual designs rely on reliable mechanical arrangements. However, such mechanisms sometimes require that operators get close to potentially dangerous motion tasks — and manually actuate heavy loads.
When considering motion control devices, the following items can apply:

- **Load limiters** – Devices to control the maximum load (including clutches, current sensing, pressure sensors and load cells).

- **Positioning feedback** – Used to confirm proper application positioning and synchronization it with other application operations.

- **Backup safety devices** – Devices (including gates, emergency shutoffs and safety circuits) that protect operators and machinery in the event of misuse or failure.

- **Safety factors** – Design the application for forces that do not exceed specified limits.

- **Ergonomic evaluation** – Includes analysis of all human interaction with the machinery, to anticipate and prevent injuries.
Section Six: Economic Factors

As mentioned, sometimes the selection of electric linear actuators, hydraulic systems or manual operation can come down to the costs of the solution. In some applications there is simply no capacity to include the costs of anything more than a manually operated system in the design. This section identifies some of the considerations of the cost of a system:

- **System costs** – Associated with the motion device, including its controls and subcomponents. Other costs include those associated with inventoried repair parts, multiple vendors or subcomponents sourced from different manufacturers and the amount of space required for the design.

- **Installation costs** – Associated with the system’s installation, including any temporary loss of production, setup of motion controls, initialization and (in the case of hydraulics) filling supply lines with fluids, priming and confirming proper system operation with adjustments as needed.

- **Design costs** – Associated with the costs of engineering software plus analysis executed by engineering personnel tasked with the system design.

- **Validation costs** – Associated with testing and validating that the solution is appropriate for the intended use with respect to all other considerations (such as temperature, failure modes and lifetime expectations).

- **Preventative maintenance costs** – Associated with maintenance of the system prior to a system failure.

- **Failure costs** – Associated with the repair and replacement of the motion control device. Should also include the cost of the downtime due to the failure, as well as those related to its evaluation, where applicable.

- **Warranty costs** – Associated with the warranty given on the motion control device or system relative to the warranty given for the application.

- **Quality costs** – Associated with poor quality from suppliers including line rejects, corrective actions, incoming inspections and so on.

- **Purchasing costs** – Associated with selection and approval of a supplier including site audits, logistic costs, taxes and duties.

- **Operating costs** – Associated with the energy required to operate the system over a specific period of time.
This whitepaper identifies many considerations useful for evaluating motion-control options, but does not provide an all-inclusive list of design factors. Actual design specifications and how they are prioritized vary with the specific application at hand. For specific questions and design assistance, please contact a LINAK applications engineer at (502) 413-0320 or visit www.linak-us.com/techline.

LINAK is an industry leader in linear actuators and linear motion solutions. The company has a global understanding of various technologies and how they are applied.
What the LINAK actuators do for the combine harvester

TECHLINE® actuator systems provide advanced motion control with superior position feedback for a number of different applications.

The list of possible actuator solutions to improve ergonomics, comfort and productivity is virtually endless.

- **Grain tank covers**: Grain tank extension and / or open and close the grain tank covers for inspection.
- **Trencher**: Engage and disengage of the trencher unit.
- **Auger**: Bend the unloading auger in transport situations.
- **Sieve**: Grain sieve adjustment to keep the sieve in horizontal level when operating in hill areas.
- **Outlet**: Wind compensation, changing directions of the outlet i.e. in heavy side wind situations.
- **Cutter**: Engage and disengage the cutter unit.
- **Header**: Forward and backward movement as well as speed regulation.
- **Concave**: Concave adjustment depending on the crop.
- **Sieve mesh**: Adjustment of the size of the sieve mesh depending on the crop.
- **Blower**: Airflow adjustment of blowers.
- **Ladder**: Access ladder extension or retraction, or have an angle on the ladder for easy access.
- **Natural ventilation**: Open and close the cabin roof.
- **Steering column and driver seat**: For easy access and comfort during operation.
Global presence

LINAK has a well-developed sales and service organization in Europe, America, Asia and Australia. Therefore, we can assist you and your customers locally, under the global sales concept idea: Be global, act local.

For further information, please visit our website:
www.linak-us.com/techline