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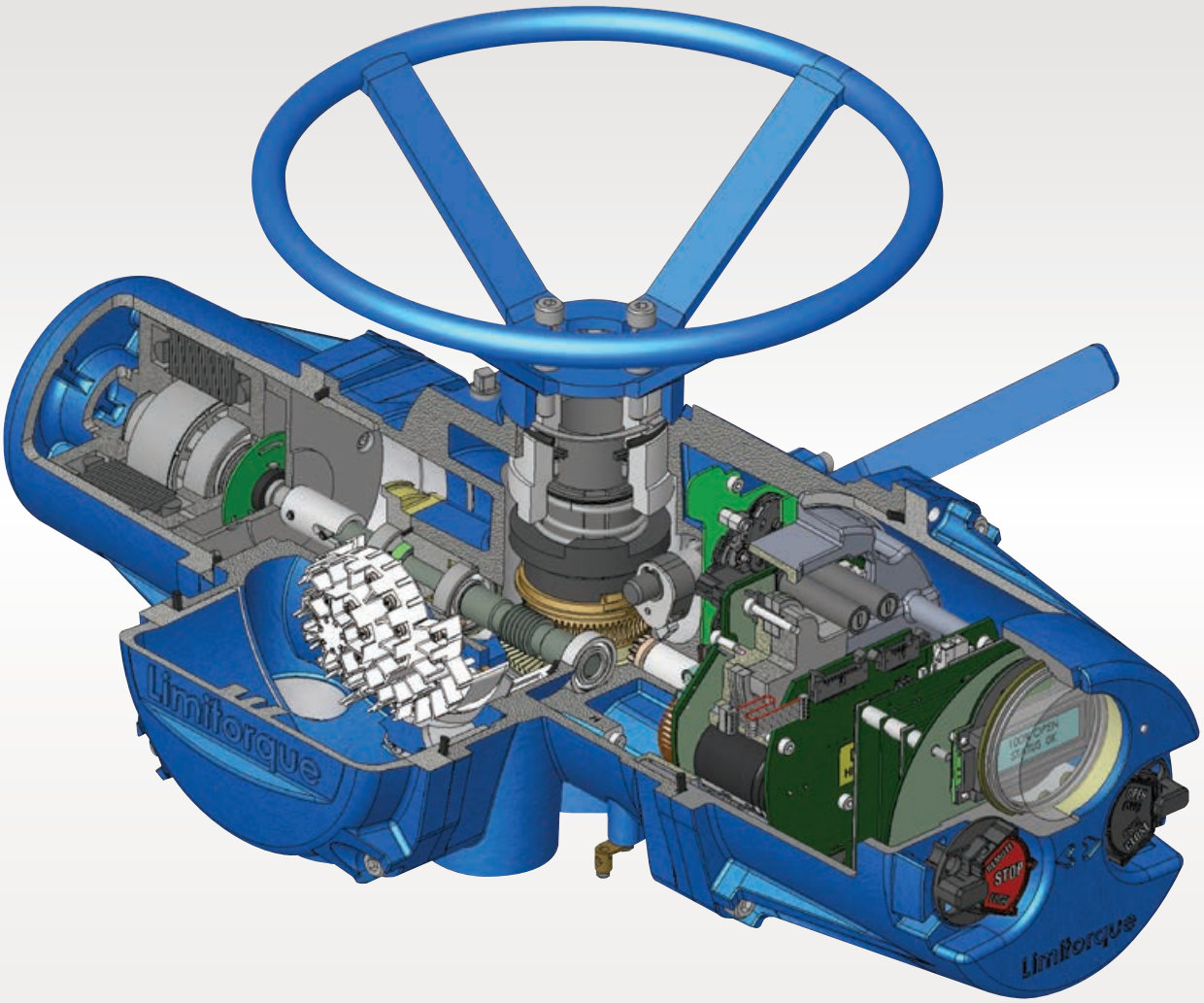
WHITE PAPER

Intrusive vs. Non-Intrusive Electric Actuators

Which option is right for your installation?



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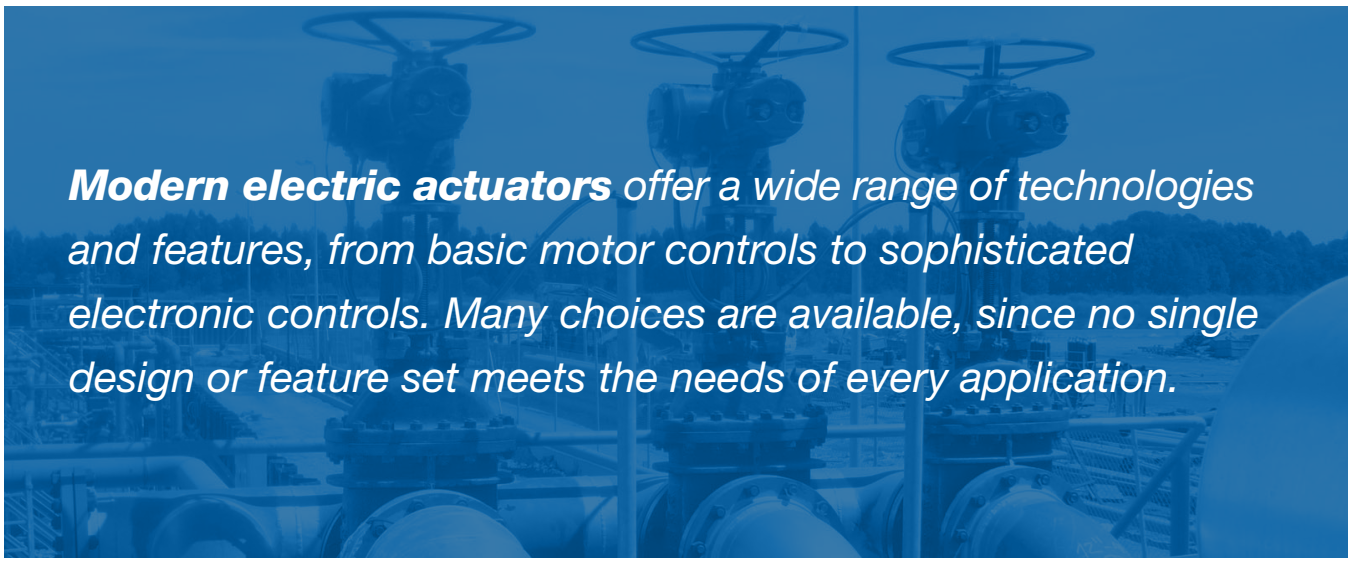

***Modern electric actuators** offer a wide range of technologies and features, from basic motor controls to sophisticated electronic controls. Many choices are available, since no single design or feature set meets the needs of every application.*

EPCs and end users must carefully weigh a variety of factors to determine which type of electric actuator will provide the greatest value to them. Common concerns include:

- Product quality, reliability, safety and durability
- Desired functionality and feature sets
- Climate conditions and atmospheric hazards (such as the presence of combustible gases)
- Workforce training and experience
- Ease of installation and use
- Valve position and torque output indication
- Anticipated total cost of ownership
- Maintenance intervals
- Local support options (on-site commissioning, service, availability of parts, etc.)

The purpose of this paper is to help make these decisions easier by providing a clear overview of the two major categories of electric actuators — Intrusive and Non-Intrusive — and how each meets the requirements of different types of user applications.

What does an actuator do?

Actuators are motorized gear drives that control the operation of multi-turn valves, slide gates and dampers; or quarter-turn valves and dampers. Some actuators, including those compared in this paper, use electricity as a power source. Other types of actuators, such as those powered by hydraulic fluid or pneumatic pressure, are not addressed in this paper.

Applications vary, requiring the user to select some form of actuator control system. Typical control systems range from simple electro-mechanical controls found in intrusive actuator designs, to solid-state electronic controls found in non-intrusive designs.

Two approaches to actuator design

Electric actuators can be classified into two basic categories: intrusive and non-intrusive

Intrusive actuators

Intrusive actuators are electro-mechanical devices with all controls and components typically combined in a single compartment. In this model, the control compartment enclosure must be opened to adjust either the position limits (the physical locations for valve disk or slide gate travel from “fully open” to “fully closed”) or the torque limits (limiting the rotational force required to open or close the valve or slide gate).

Many intrusive actuators come equipped with a mechanically controlled external display that indicates the current position of the valve disk or gate slide, though this is an optional feature on some models. Some manufacturers also offer an external graphical display that provides additional information, such as troubleshooting data.

Motor controls are an optional feature on intrusive actuators. When provided, these include an electro-mechanical reversing starter, control transformer, and a local control station that allows the valve or gate to be operated either locally or remotely.

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Figure 1: *Intrusive actuators consolidate all controls in a single compartment that must be opened to perform actuator and valve setup. Since they are typically electro-mechanical, they perform more reliably in some environments.*

Two approaches to actuator design *(continued)*

Non-intrusive actuators

First introduced in the 1990s, non-intrusive actuators have electronic controls located in a separate sealed enclosure integral to the actuator. Position and torque limits can be set without opening the control compartment, using integral Hall-effect or hand-held electronic devices and an LCD display to configure these limits. This digital interface also enables additional control and diagnostic features not available on most intrusive models.

Motor controls, which are an optional extra on intrusive actuators, are standard on non-intrusive models. At a minimum these include an electro-mechanical or electronic reversing controller, a control transformer, a local graphical display, and circuit board technologies that enable basic and expanded feature sets.

Position indication is derived electronically from encoders using either optical or Hall-effect devices.

Before discussing the strengths and limitations of each type of actuator design, it is worth mentioning that this paper makes no claims suggesting that one is superior to the other. Both designs have proven reputations, but each typically excels under different conditions.

…non-intrusive actuators have electronic controls located in a separate sealed enclosure within the actuator. Position and torque limits can be set without opening the control compartment…

Figure 2: *Non-intrusive actuators allow adjustments to be made without risk of exposure to internal components. They contain electronics that require separate compartments for field terminations and control components.*

Intrusive designs

Benefits

- All controls and terminations are located inside a common compartment cover, which simplifies installation and maintenance. In most designs, necessary setup and inspections can be performed with volt meters and simple hand tools.
- The electro-mechanical design of intrusive actuators enables valve positions and torque output limits to be set mechanically. This provides long-term reliability and repeatability for both position and torque control. It also ensures that the position of the valve is maintained in the event of a power failure.
- Intrusive designs are easier to operate, requiring only basic control functions with local or remote indication of the valve or gate position. Optional control features that add network control are available from most manufacturers.
- Motor controls can be mounted remotely from the actuator, a significant benefit in high-vibration or extreme temperature applications.
- Electro-mechanical designs are more resilient to lightning strikes, which can threaten the proper operation of the actuator.
- Intrusive designs are virtually maintenance-free, delivering a long-term low cost of ownership.

Limitations

- The control compartment must be opened in order to set up an intrusive actuator. This is a significant issue in explosive environments.
- Intrusive actuators from most manufacturers offer less sophisticated feature sets. If upgraded functionality is required and intrusive actuators are already installed, the user may need to replace them with non-intrusive models.
- Most intrusive actuators provide minimal diagnostic feedback, making troubleshooting more difficult. Performance tracking is also not an option from most manufacturers.

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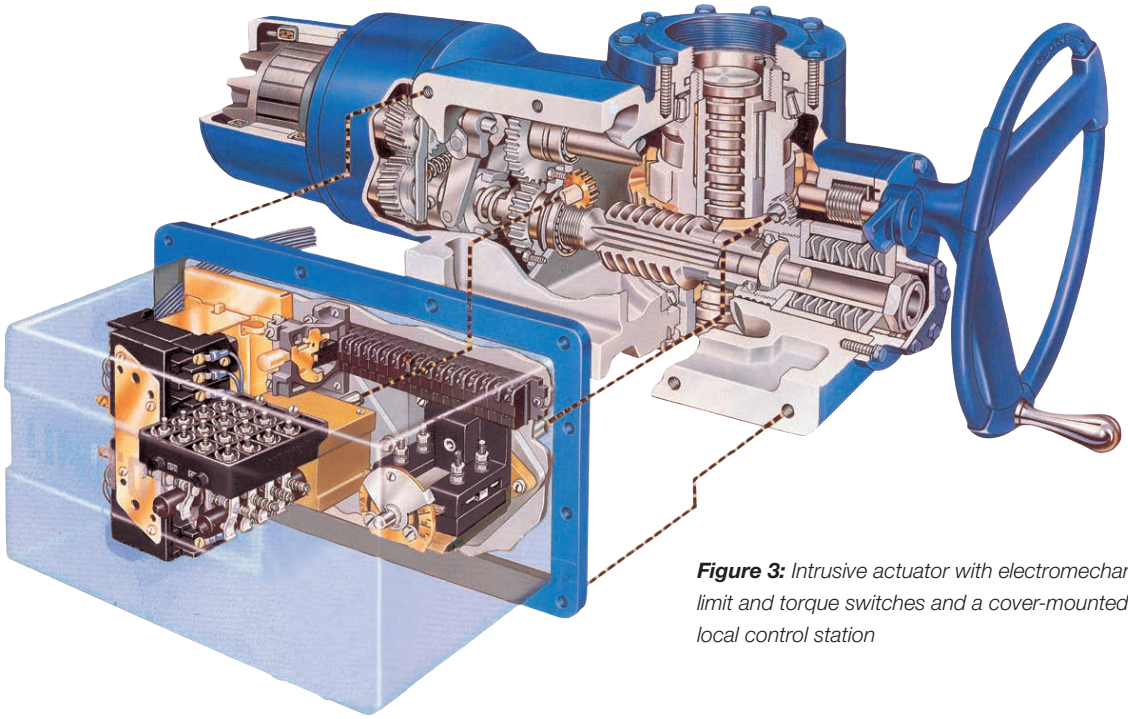

Figure 3: *Intrusive actuator with electromechanical limit and torque switches and a cover-mounted local control station*

Non-intrusive designs

Benefits

- An on-board graphical display is used for a non-intrusive actuator's setup and commissioning. It also provides status information, position indication, and overall health data through diagnostic feedback without the need to open the control compartment.
- Non-intrusive designs offer significantly more robust feature sets and configuration options. For example, actuator troubleshooting and control data can be provided in multiple languages, depending on the needs of the user.
- Status and alarm conditions (such as open, close, moving, over torque, manual valve movement, stall, etc.) can be reported on the graphical display, either as contact closures or digital data.
- Separate terminal and control compartments are provided, allowing the actuator to be wired without exposing the electronics to possible damage from dust and moisture in the atmosphere.
- External setup and commissioning reduces the risk of explosion in hazardous environments, where combustible gases may be present.
- Non-intrusive actuators offer a finer degree of device position control. This is made possible through the use of encoders. See sidebar on page 7.
- Networking controls are optional on non-intrusive designs, making them easier to integrate into remote-control systems.

Limitations

- The onboard electronics of non-intrusive actuators make them more susceptible to the effects of close lightning strikes.
- Non-intrusive actuators have separate compartments for controls and wiring terminals, which in rare circumstances can require the removal of both covers if modifications or repairs are to be made.
- Manufacturers assume that users will not need to open the controls compartment. End users require more specialized training and tools to perform maintenance and adjustments beyond those enabled by electronic controls.

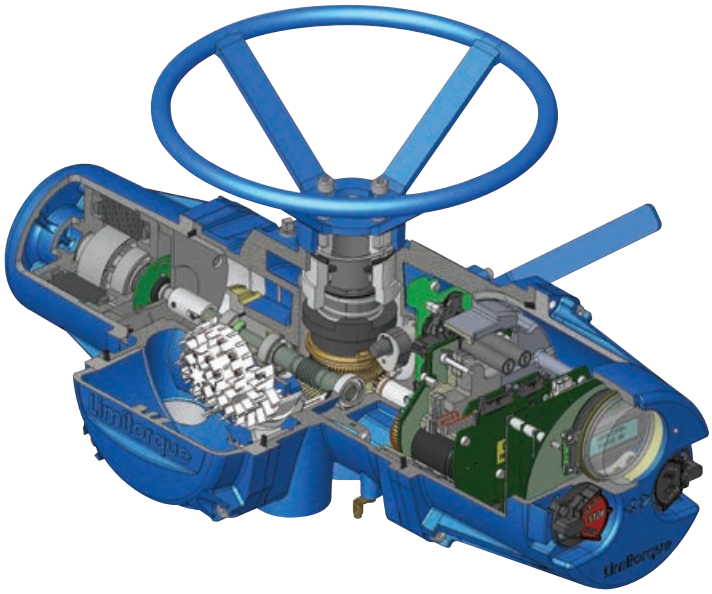

Figure 4: *Non-intrusive actuator with graphical display, absolute encoder, and circuit board technology for status and diagnostics*

Non-intrusive designs offer significantly more robust feature sets and configuration options. For example, actuator troubleshooting and control data can be provided in multiple languages, depending on the needs of the user.

What is an encoder?

Encoders are devices that set precise positions in response to electronic signals. There are two types of encoders: absolute and incremental. Absolute encoders, which set specific positions without requiring any data about the current device position, offer superior reliability because they retain their valve or gate position settings in the event of a power failure. While actuators with incremental encoders offer comparable precision, they must count cycles to retain an absolute position. As a result, they require battery packs to maintain their settings during a loss of power.

Final thoughts

Neither type of actuator detailed in this report is necessarily better than the other. While the industry seems to be making a slow and gradual shift toward the newer technology of non-intrusive actuators — especially in greenfield projects — intrusive models still play a significant role, both at new and existing sites.

Ultimately, the design chosen will be driven by the specific needs of your application. Highly networked sites are likely to lean toward non-intrusive models, while those requiring simpler controls may be better served by intrusive options. Some environmental conditions — such as frequent lightning strikes, extreme temperatures or vibration — are likely to be better served by intrusive designs. In other environments — especially those with explosive gases or high levels of dust, sand or moisture — non-intrusive designs offer significant safety and maintenance advantages.

In situations where neither design seems to offer a clear advantage, compare your site's needs and resources to the benefits and limitations detailed for each type. Weigh the desired functionality against the cost of ownership for the actuators offered by your preferred manufacturers. A specific feature set, ease of use, configuration options, durability, value, and the level of sophistication (or simplicity) you need are likely to indicate which solution is best for your unique application.

Flowserve can help

Unsure whether an intrusive or a non-intrusive electric actuator is right for your application? We want to help.

Flowserve Limitorque electric actuators are offered in intrusive and non-intrusive designs, and with numerous optional upgrades to address various process, networking and operational needs. We know there are many of factors to consider and understand selecting the right actuator for an application can be confusing. Our actuation experts are available to provide counsel on your application requirements.

Please contact your local Flowserve Limitorque sales representative to learn how we can help. Contact details can be found at **Flowserve.com**.

About the authors

Earnest Carey

Earnest (Earnie) Carey, Jr. has been with Flowserve Limitorque for more than 35 years in roles of increasing responsibility. He has been the principal portfolio manager for Flowserve Limitorque since 2010. Earnie started his tenure as a test engineer involved with environmental qualifications of safety-related electric actuators in the 1980s. He moved to product development in the early 1990s and has been the product manager of the Flowserve MX and QX non-intrusive actuator product lines since 1998.

His educational background is mechanical engineering technology and he has authored several white papers, including a discussion of the need for B.I.S.T. (Built In Self Test) designs in smart actuator absolute encoders. Earnie is an active member of the VMA and BVAA, and has authored and presented technical papers at ACHEMA

David Montgomery

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Dave Montgomery is a senior product manager for electric actuation products. Over his 38-year tenure with Limitorque and Flowserve Corporation, he helped develop project management software and has worked as a senior applications engineer and manager of water industry sales. He currently manages the Flowserve intrusive design of SMB and L120 electric actuators, and three gearbox lines.

In his career, Dave has authored a white paper on actuator commissioning, co-presented a discussion on actuators for cokers, and for several years taught actuator sizing and application to nuclear industry engineers. In addition, he served for 10 years as chair of the American Water Works Association subcommittee on the revision of the ANSI/AWWA C542 standard for Electric Motor Actuators for Valves and Slide Gates.

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FLS-VA-EWP-00001-EN-EX-US-0518 (E) May 2018