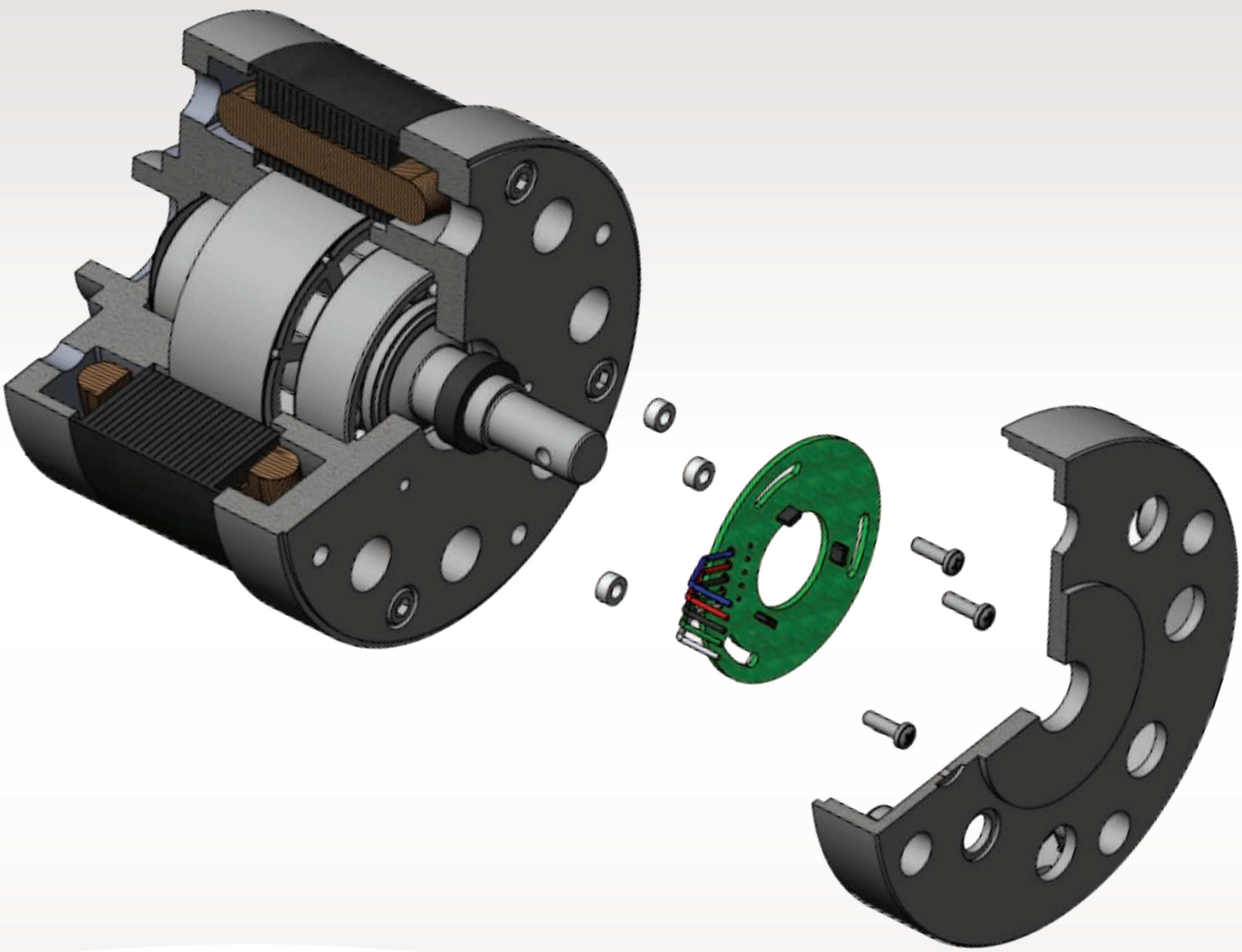
WHITE PAPER

Ten Reasons to Consider Brushless DCV Motors in Electric Valve Actuators



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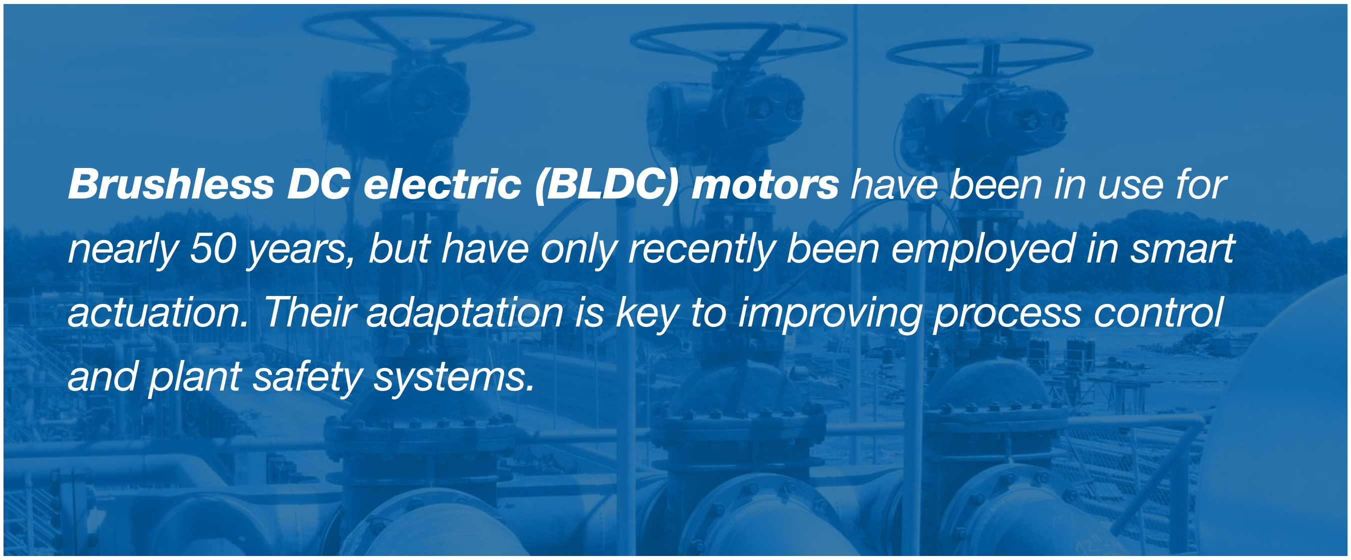


***Brushless DC electric (BLDC) motors** have been in use for nearly 50 years, but have only recently been employed in smart actuation. Their adaptation is key to improving process control and plant safety systems.*

Safety and efficiency are critical in the control of plant systems, as each field device is expected not only to meet but to exceed user specifications. The growth of fieldbus technologies has enabled real-time component performance tracking and the need to optimize networked responses.

As a result, previously acceptable levels of performance for electric actuators no longer satisfy user expectations. Better precision, safer and quieter electrical operation, and improved longevity are now minimum requirements. All of these attributes are integral to electric valve actuators with BLDC motor technology.

The purpose of this paper is to explore the latest innovations in these motors, consider alternatives, and discuss how to make an educated decision regarding when and where to use BLDC motor technologies.

What is a brushless motor?

Brushless DC motors are synchronous motors powered by a DC source using an electric controller instead of the brush/commutator mechanism found in brushed DC motors. The electric controller — an integrated inverter/switching power supply — produces an AC signal that drives the rotor. See Figure 1 for an illustration of a typical BLDC motor.

They are also known as electronically commutated motors, ECMs or EC motors.

The emergence of BLDC motors

AC and DC volt motors have been used for valve actuation since 1929. Motor technology remained virtually unchanged for years until the 1960s, when the evolution of brushless DC motor technology progressed to make them commercially attractive. However, it was not until the mid-2000s that BLDC technology was integrated into electric valve actuators.

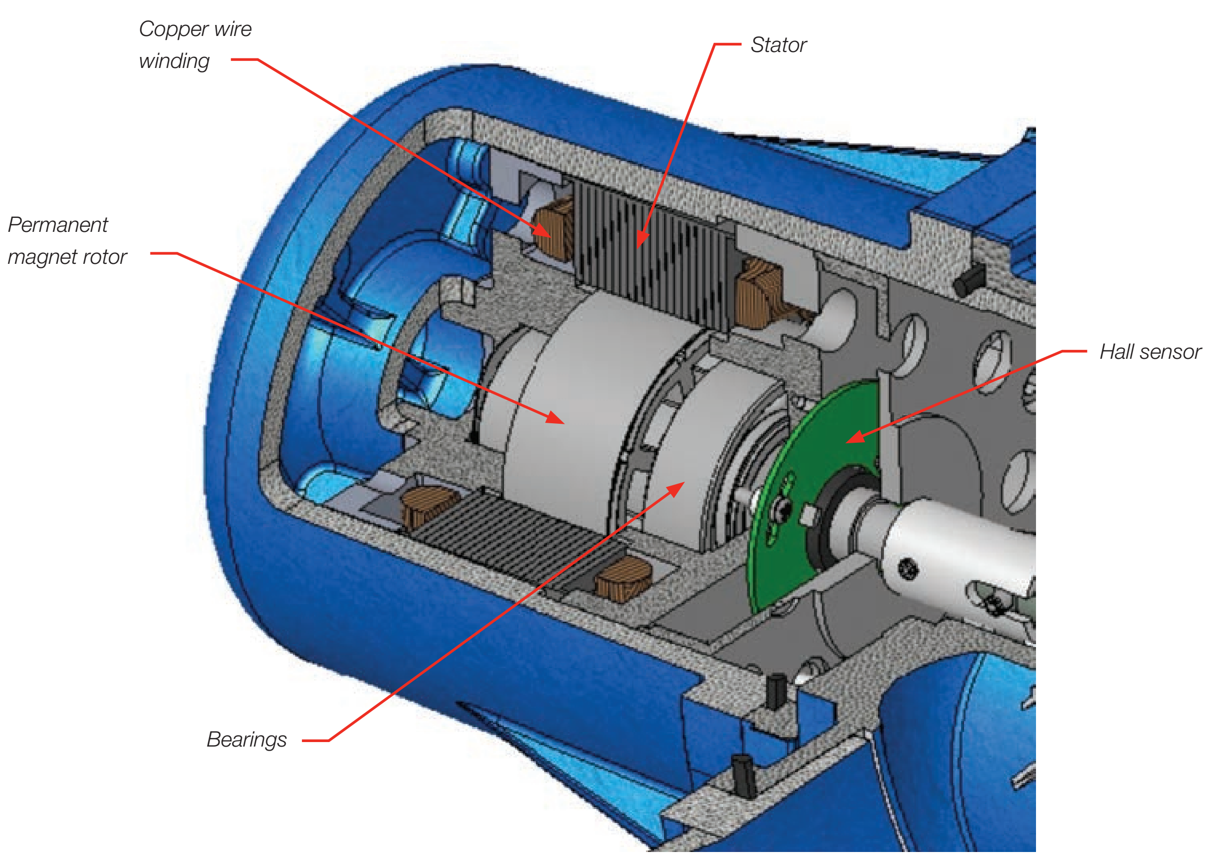
While BLDC motors require electronics to drive them, they are virtually maintenance free, highly efficient and cost competitive in smaller torques. Early BLDC motors were limited to about 0.5 hp (0.373 kW), but are now capable of producing power up to 135 hp (100 kW). They are routinely used in applications that demand high degrees of positioning accuracy. Their performance characteristics exceed ACV motors in efficiency, starting torque, size to power ratio, and speed and position control. Since 2007 several electronic actuator OEMs have designed new products with BLDC motors.

Smart electronic actuators were developed to meet increasing user demand for safe and reliable electronic control, and have been in use for approximately 20 years. BLDC motors employ sophisticated electronics such as motor controllers for control and safety.

Their advantages include:

- Low maintenance (no brushes)
- Variable operating speeds and fast response times
- High efficiency, resulting in cooler performance
- Compact size
- Compatible with AC voltage (ACV) and DC voltage (DCV) industrial power buses

Figure 1: *Typical BLDC motor*

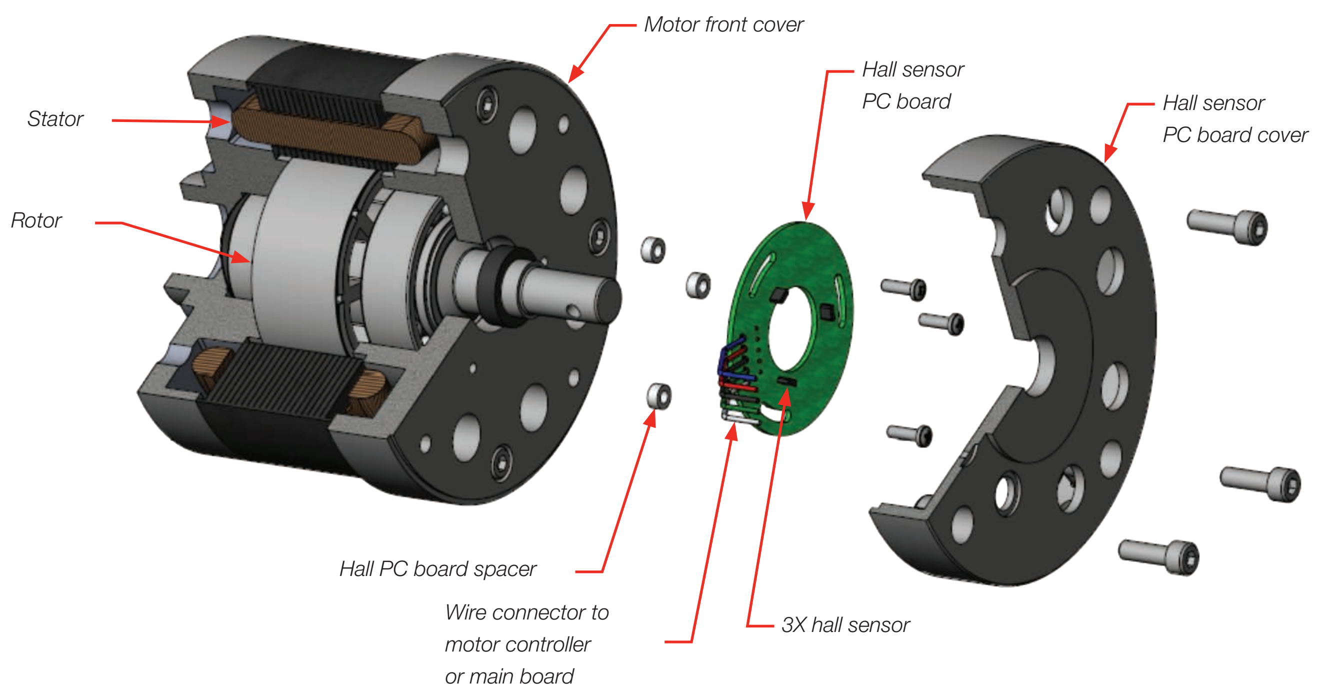


BLDC advantages

1. **Motor speed regulation:** An inherent advantage of the BLDC motor is the use of Hall-effect devices for determining rotor speed and positioning. Fundamental to the performance of the motor, they regulate motor speed by providing immediate and accurate rotor position feedback to the motor controller. (See Figure 2.)
2. **Rapid variable response:** BLDC motors respond like ACV motors with variable frequency drives but without the electro-magnetic interference (EMI) components and can change speed rapidly and precisely because of their electronics. For example, a maximum 3000 RPM motor can vary its speed down to 200 RPM and subsequently accelerate to 3000 RPM, depending upon a signal received from the motor controller.
3. **Improved speed and positioning:** An actuator with a BLDC motor that incorporates encoder feedback significantly enhances the device's ability to control both speed and position. Absolute position encoders are essential components used to determine both actuator speed (RPMs) and exact position and should have at least a resolution of 12 to 18 bits for precise positioning. The speed and actuator position control are further improved when supplemented by encoders.

BLDC motors require electronics to drive them, they are virtually maintenance free, highly efficient and cost competitive in smaller torques.

Figure 2: *Exploded view of a BLDC motor, including the Hall-effect sensors, alignment cover and sensor PCB*



BLDC advantages *(continued)*

4. **Alternative energy-friendly:** The use of 24–48 VDC is especially important for alternative energy markets such as the solar power industry or industries that use battery power.
   - **NOTE:** A BLDC motor operates on either ACV or DCV mains. Since the vast majority of industrial global voltage inputs are ACV, a rectifier is required to convert both single- and three-phase ACV inputs to drive the BLDC motor. The electronics must have the capability to rectify up to 600 Vac for the BLDC motor bus voltage. Additionally, it should be able to convert 125–250 VDC and 24–48 VDC supply.

5. **Electronic controller precision:** The motor controller electronics that drive BLDC motors offer significant advantages of precision compared to electro-mechanical devices. Electronic motor controllers also maximize efficiencies in that they are precisely sized to match the power capability of the motor.

When communicating with mating motor controllers and other processors, BLDC motors offer superior performance and reliability in addition to accurate speed control and precise valve positioning.

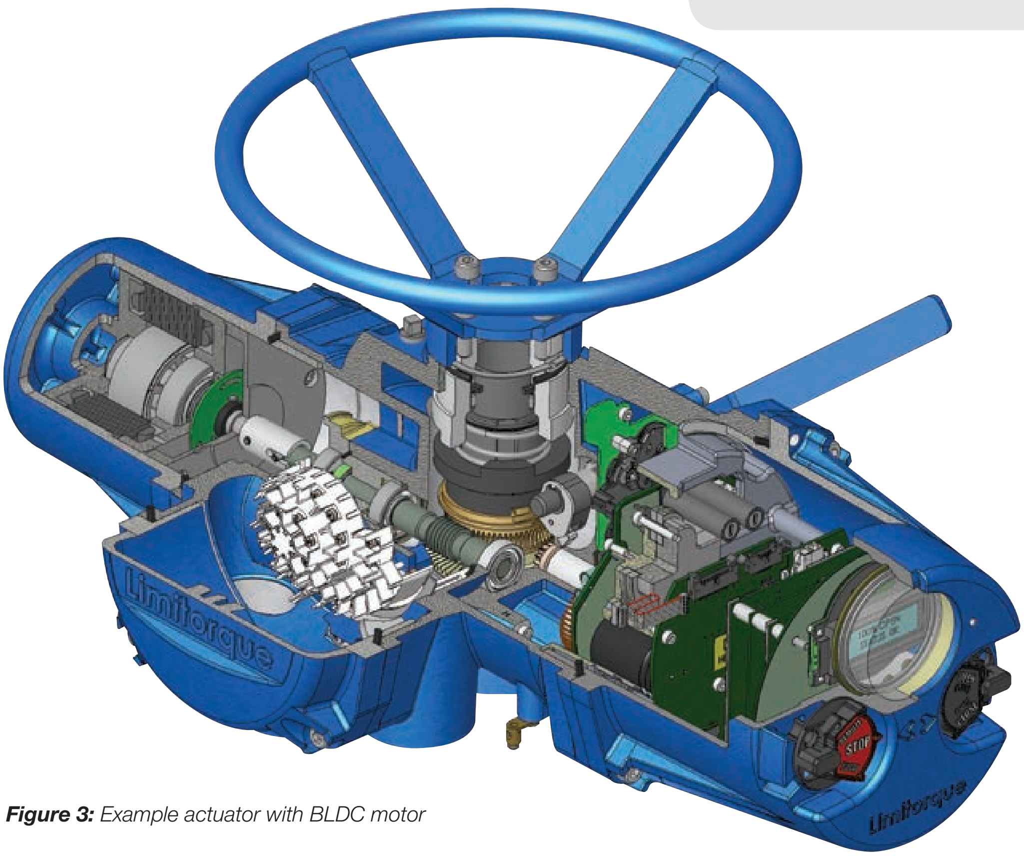


Figure 3: *Example actuator with BLDC motor*

BLDC advantages *(continued)*

6. **Well-suited for process control applications:** BLDC motors can be used for virtually any global voltage requirement for on-off valve control. However, their primary benefit is in process control applications.
   - Electric actuators are equipped with an internal 4-20 mA controller that corresponds to a process position signal received from plant instrumentation for "modulating" applications. Initially, performance was limited to about 60–100 motor contactor "starts" an hour, but today many process requirements can perform up to 1200–3600 "starts" per hour.
7. **Low-temperature operation:** BLDC motors can operate at lower temperatures than ACV motors, partly because of the absence of brush friction as well as their smaller size per torque output design ratio. The ability of BLDC motors to run cooler and dissipate heat more rapidly while operating almost continuously is critical to electronic actuators exceeding 1800 starts per hour.
8. **Eliminate EMF interference:** BLDC motors do not spark because they lack brushes. This solves a major problem with DCV motors: brushes generate electrical noise, causing EMF (electro-magnetic field) interference. Instead, a BLDC motor uses electronic sequencing of motor current, eliminating the sparks caused by troublesome brushes. This makes BLDC motors more likely to be compliant with global explosion-proof certifications. EMI reduction is important because it satisfies certain European Directives, which have rigorous conducted and radiated emissions envelopes.
9. **No special power supply requirements:** Regardless of the plant's power supply (AC or DC), the BLDC's electronic motor controller converts the power to an acceptable input voltage level to power the motor. This means no special rectifiers are needed, simplifying installation requirements.
10. **Cost competitive:** While the cost of some BLDC motors is still a bit higher than ACV motors, ongoing cost-to-benefit ratio improvements make their total technology costs virtually equal. This combination of superior performance at a competitive cost is already driving a trend to replace other types of motors with BLDC devices.

Application consideration

Heat dissipation: While BLDC motors operate cooler than other types, the thermal transfer of the motor's power can contribute to motor controller heat. A sufficient thermal "chill" is needed to dissipate their heat. Well-engineered motor controller designs include heat dissipation, overcoming this limitation.

Alternatives to brushless motors

In addition to BLDC's, electric actuators may also use the following motor technologies:

- **Permanent magnets** — have excellent start torque and good speed regulation but are limited to the amount of load they can drive. For this reason, most permanent magnet motors are small and typically are brushed motors.
- **Series motors** — can develop a large amount of starting torque but supply very little speed control. While suitable for constant speed and load applications, they cannot be used if either the load or the speed varies.
- **Shunt motors** — offer good speed regulation because the field winding (shunt) can be excited separately or connected to the same source as the armature (series field). They feature a simplified control system for motor reversing and are used in a variety of applications.
- **Compound wound motors** — the armature and field winding are wound separately. The series field provides better start torque while the shunt field provides better speed control; however, they are not suitable for variable speed drive applications.

Final thoughts

In conclusion, it makes good business sense — for several reasons — to consider using BLDC-powered actuators in plant systems requiring increased levels of safety and control. They are safer than ACV motors because of their cooler thermal characteristics and the absence of brushes. They are reliable, thanks to the evolution of their design over 50 years and their use in industries with stringent requirements, such as the U.S. space program and heavy machine tools. Finally, they are predictable, especially when coupled with electronic systems that work in concert with motor controllers and encoders. Although their use in electronic actuators is relatively new, the advantages they offer will contribute to a gradual replacement of most other motor types in the coming years.

Flowserve can help

Unsure whether a BLDC motor is right for your electric actuator application? We want to help.

Flowserve Limitorque® offers knowledge and expertise when trying to determine the appropriate motor type for actuator applications. 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 author

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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

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