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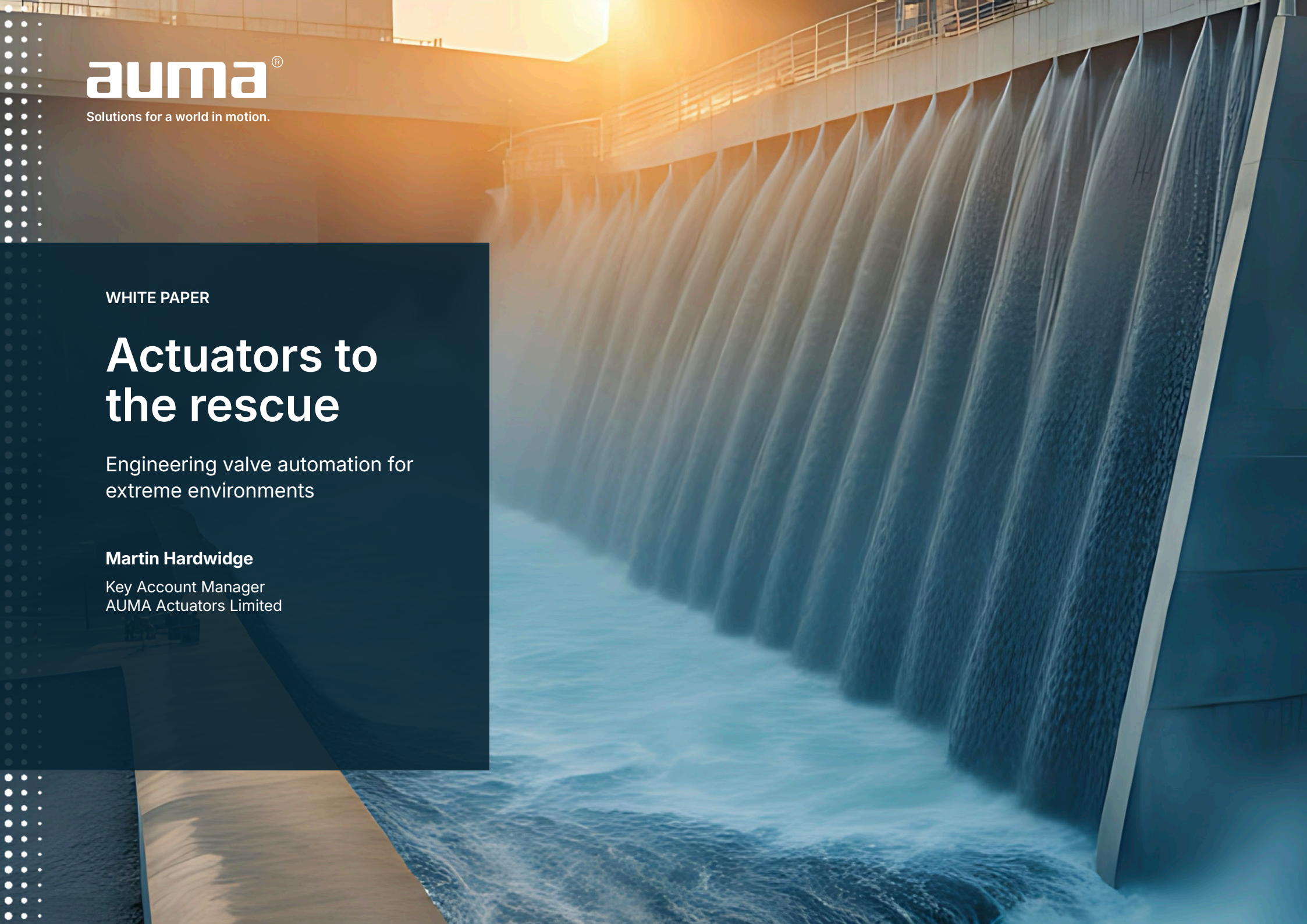
WHITE PAPER

Actuators to the rescue

Engineering valve automation for
extreme environments

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When routine automation becomes mission-critical

In extreme environments, the challenge is predictable performance throughout service life.

Valve automation is often taken for granted. In many applications, an actuator simply opens or closes a valve as part of a routine industrial process. Yet in some of the world's most demanding operating environments, actuators become mission-critical safety devices, engineered to overcome the toughest challenges.

Electric actuators are increasingly required to deliver reliable performance under conditions far beyond those encountered in conventional industrial applications – from Arctic temperatures to desert heat, from explosive atmospheres and submerged installations to nuclear facilities and naval vessels.

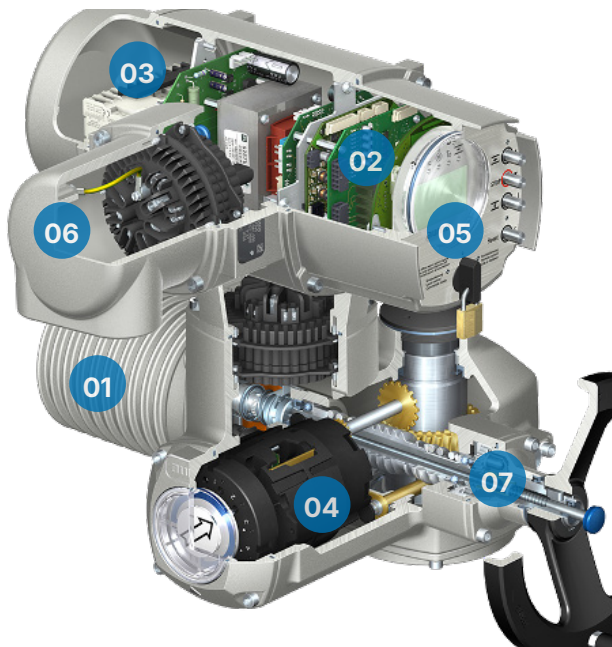
The engineering challenge is not simply making an actuator work. It is ensuring it continues to perform predictably throughout its service life, regardless of the operating environment.

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Environmental engineering extends far beyond the external enclosure."



01 Motor 02 Circuitry 03 Relays & contactors 04 Positioning systems 05 Display 06 Electrical connections 07 Worm gear

More than just a motor

The British Valve and Actuator Association (BVAA) defines an actuator as 'an operating element that uses electrical, hydraulic or pneumatic power'. While technically correct, this simple definition hides the complexity of a modern electric actuator.

Today's intelligent electric actuator is a sophisticated electromechanical system comprising a motor, gearing, electrical circuitry, relays and contactors, positioning systems, displays, electrical connections and electronic control systems. Every one of these components can be affected by the operating environment, meaning environmental engineering must extend far beyond the external enclosure.

Designing for hostile environments requires engineers to understand which individual components are vulnerable and how they behave under extreme conditions.

Engineering for extreme temperatures

Many industrial valves are expected to operate in locations where temperatures extend well beyond normal ambient conditions. The actuator mounted on that valve must perform with the same reliability.

A typical electric actuator is designed for operation between -40°C and +70°C. However, specialist applications may require reliable operation at temperatures as low as -60°C or exposure to ambient temperatures approaching 120°C, with some applications tolerating peaks of 150°C for short durations.

Whilst extreme heat and extreme cold appear to present opposite challenges, they often affect similar components.

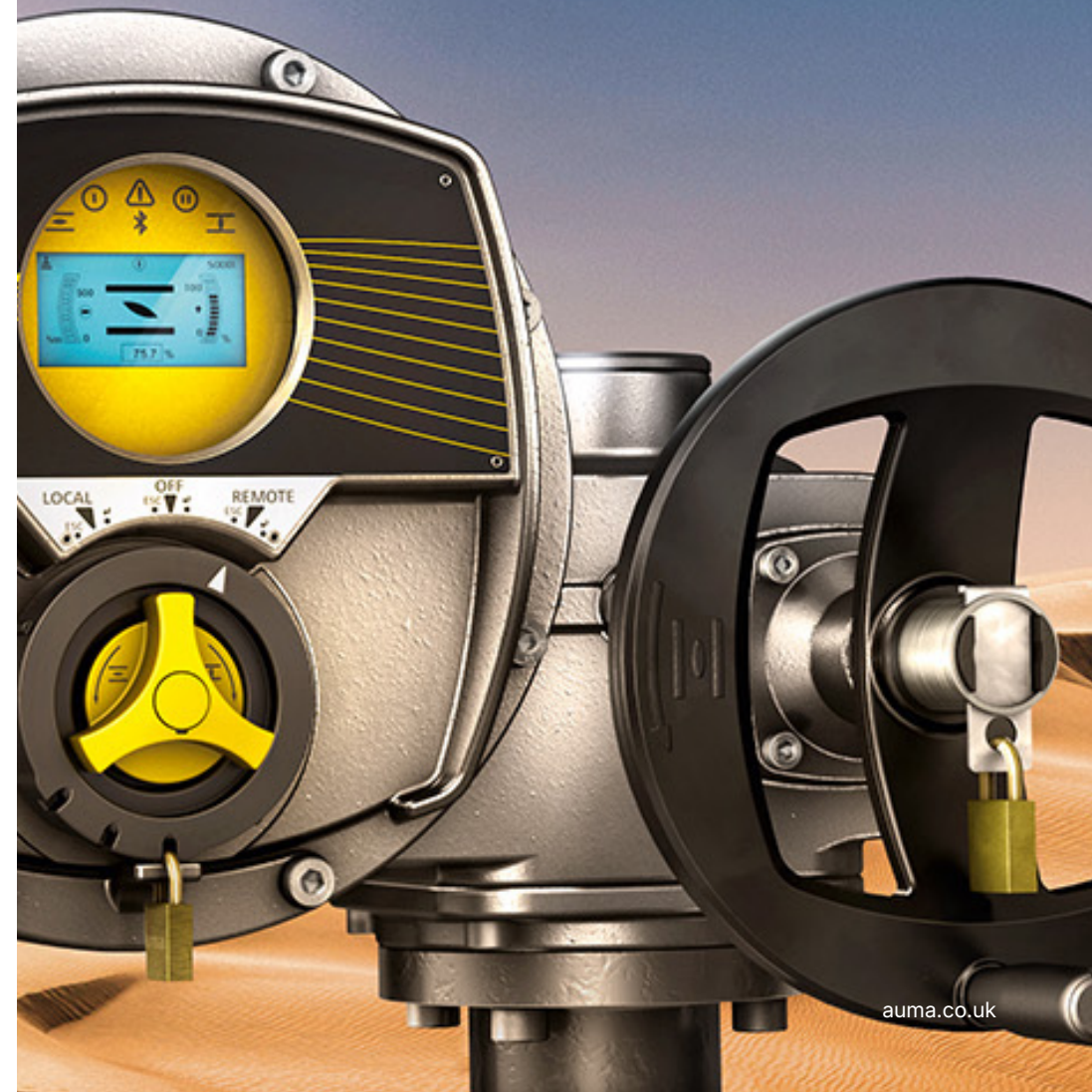


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From -60°C lows to 150°C peaks

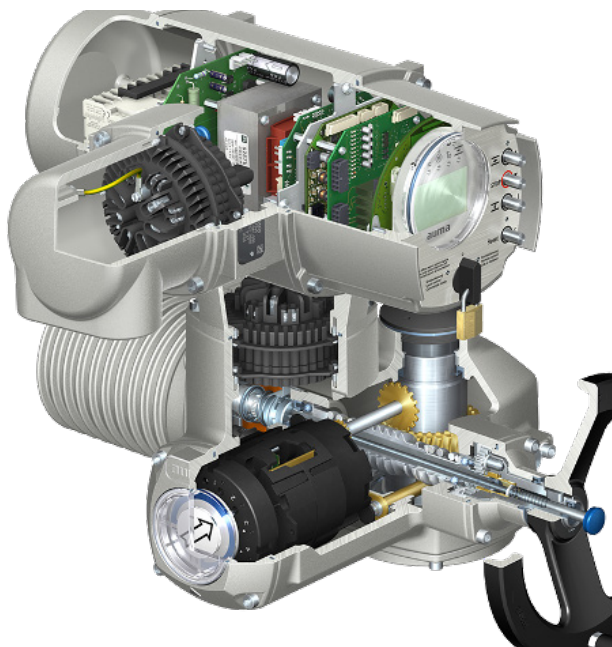
-40°C to +70°C

Typical range





There is no universal extreme-temperature design."



DESIGN VARIABLES

Motor insulation / Lubricants / Heaters / Torque & limit switches /
Electronic position transmitters / Electrical connectors / Sealing
materials / Cable systems / Electronic controls

Configure around environmental conditions

There is no universal extreme-temperature design.

The motor insulation system may require upgrading to higher temperature classifications. Lubricants must be selected to maintain their characteristics across wider operating ranges. Additional heaters may be incorporated to prevent condensation or freezing. Torque and limit switches may require alternative specifications, while electronic position transmitters may be replaced with precision potentiometers where environmental conditions demand greater robustness.

Electrical connectors, sealing materials and cable systems may also require redesign, while in the most demanding high-temperature applications, electronic controls may need to be relocated or provided with independent environmental protection.

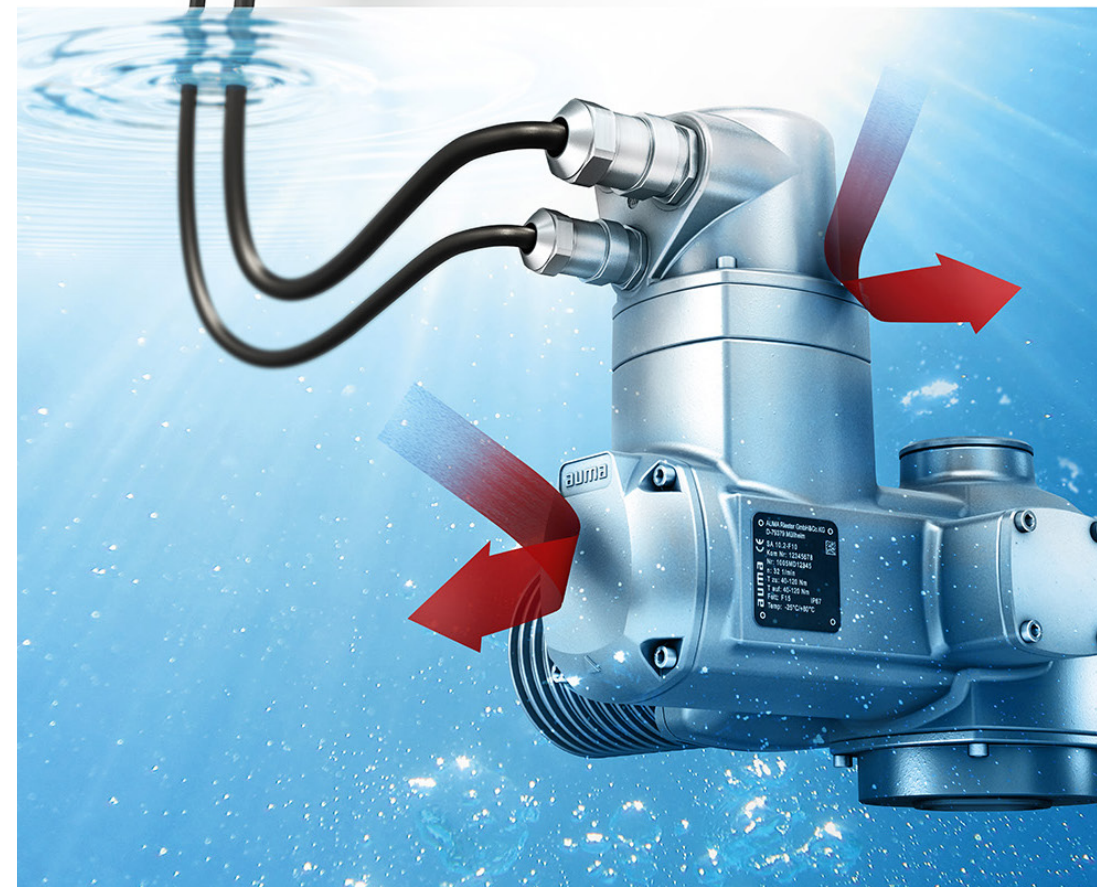
Rather than relying on one universal design, engineers must configure each actuator around the specific environmental conditions it will encounter.

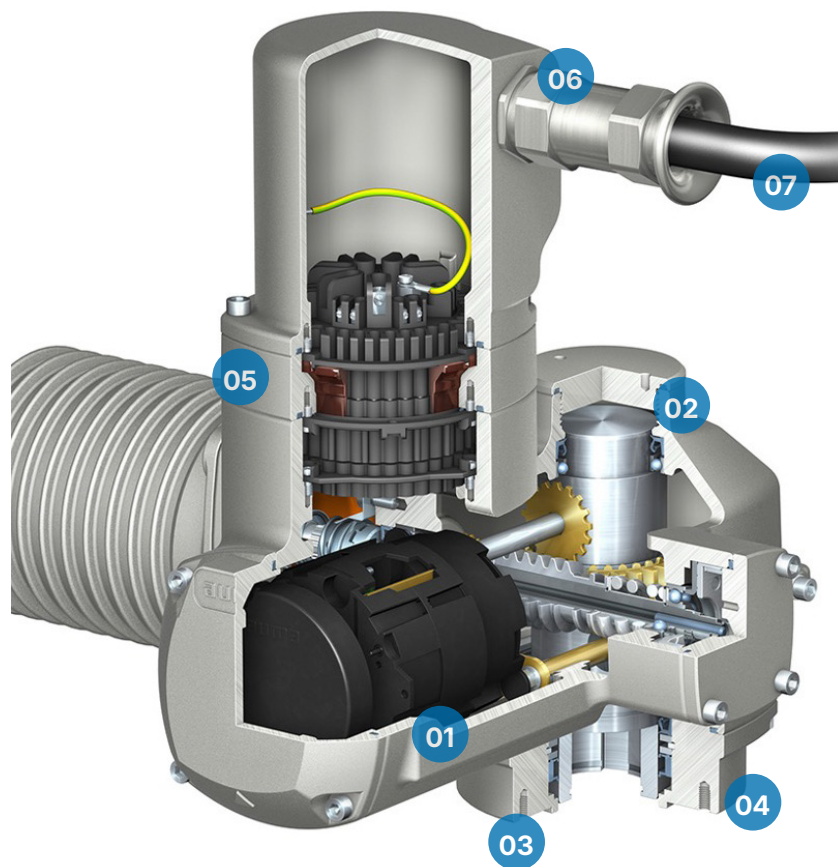
When the actuator goes underwater

Submerged valve applications introduce an entirely different engineering challenge. Unlike conventional outdoor installations, underwater actuators must resist continuous water ingress whilst maintaining operational integrity over extended periods. Achieving this requires considerably more than simply improving enclosure sealing.

Critical design features typically include double-sealed bearing flanges, double-sealed frame construction, specialised cable glands and cable assemblies, solid drive shafts and valve attachments designed specifically for submerged operation. Electronic controls are frequently housed within non-intrusive control units, allowing configuration and diagnostics without compromising enclosure integrity.

Every interface becomes a potential leakage path, demanding meticulous mechanical design alongside rigorous sealing technology.





Seven details that change the engineering

The technical cutaway identifies the physical changes required for submerged operation.

- 01 Non-intrusive electronic control unit
- 02 Solid shaft
- 03 Special valve attachments
- 04 Double sealed bearing flange
- 05 Double sealed frame
- 06 Special cable glands
- 07 Special cable set

Protection works in both directions

Environmental protection is not simply about protecting the actuator from its surroundings; it is equally about protecting the surrounding environment from the actuator itself.



DSEAR / ATEX / Ex d / Ex e



Ex d / flameproof

Contains pressure from an internal explosion and prevents transmission to the surrounding atmosphere.



Ex e / increased safety

Adds measures against excessive temperatures, arcs and sparks in normal or specified abnormal operation.

FLAME PATHS / SEGREGATED COMPARTMENTS /
REVISED CONNECTIONS / CONTROLLED SURFACE TEMPERATURE

Contain ignition. Control temperature.

In hazardous areas, reliability alone is insufficient. The actuator itself must never become the source of ignition.

Applications covered by the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) require specially certified equipment designed to operate safely within potentially explosive gas environments.

Flameproof (Ex d) protection ensures that heat generated by any internal explosion remains contained within the enclosure. Increased Safety (Ex e) protection minimises the possibility of arcs, sparks and excessive temperatures occurring during normal or specified abnormal operation.

Meeting these requirements fundamentally changes actuator design. Flame paths are introduced into enclosure construction. Internal compartments become segregated and sealed. Electrical connections are redesigned, and every aspect of heat generation must be carefully controlled to minimise external surface temperatures.

QUALIFICATION REGIME

RADIATION

1.05×10^6 Gy

THERMAL AGEING

60 year operating life

SEISMIC

OBE / SSE / DBE

ACCIDENT

LOCA + DBE

ARCHITECTURE

No local controls/software

Proven under abnormal events

Testing regimes may include radiation exposure exceeding 1.05×10^6 Gy, thermal ageing designed to simulate a 60-year operational life and vibration testing that replicates earthquake conditions, including Operating Basis Earthquake (OBE), Safe Shutdown Earthquake (SSE) and Design Basis Earthquake (DBE) scenarios.

Additional qualification testing addresses Loss of Coolant Accident (LOCA) conditions and other design basis events. The emphasis is always on proven mechanical reliability. Consequently, many nuclear actuators eliminate local software and operator controls entirely, reducing complexity whilst increasing long-term dependability.

Compact. Quiet. Shock-resistant.

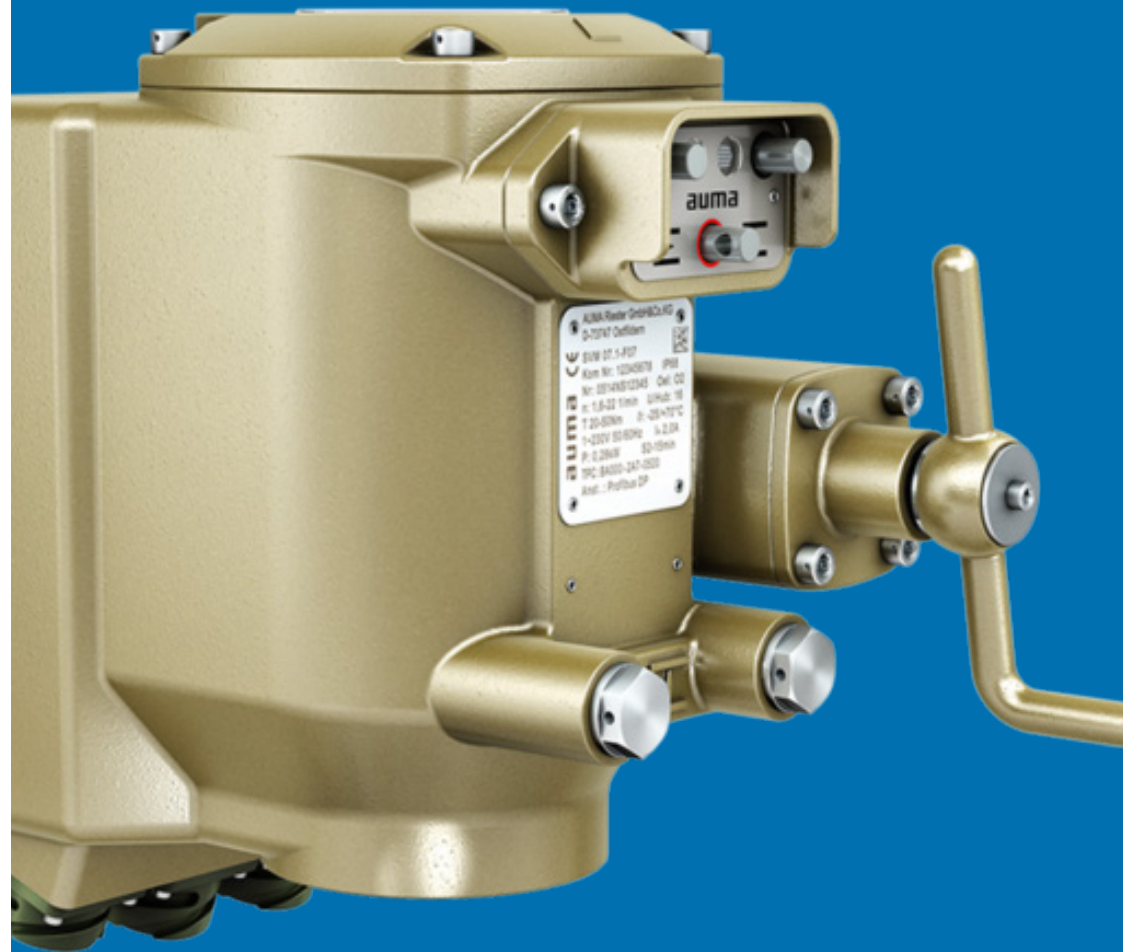
Naval environments combine many of the challenges found elsewhere with additional operational demands unique to military service.

Space constraints require compact actuator designs capable of delivering high positioning accuracy at elevated operating speeds. Materials must resist long-term corrosion from seawater whilst remaining suitable for submerged operation where required.

In specialist applications, actuators may also need to be non-magnetic and operate with exceptionally low acoustic signatures. Perhaps the greatest challenge, however, is survivability under shock loading.

Military qualification testing subjects actuators to extreme acceleration forces designed to simulate nearby explosions and weapon impacts. Depending on vessel classification, actuators may be required to withstand shock loads of approximately 180g on surface vessels and up to 400g aboard submarines.

These are conditions few industrial products will ever encounter, yet actuator performance remains essential to maintaining critical onboard systems.



180g

surface vessels

400g

submarines

A different design brief

Performance has to survive the vessel's environment as well as the valve duty.

Compact

Non-magnetic

Shock resistant

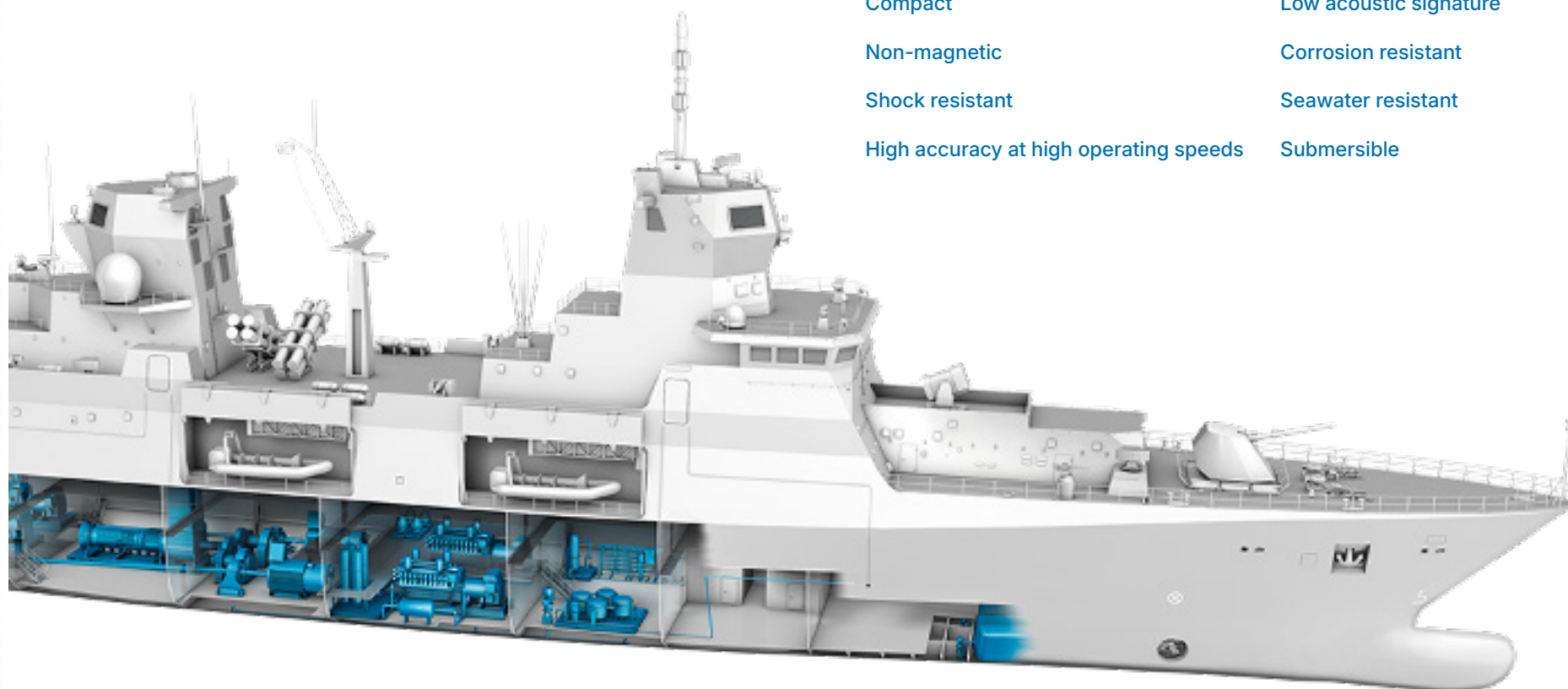
High accuracy at high operating speeds

Low acoustic signature

Corrosion resistant

Seawater resistant

Submersible



There is no universal solution

Every extreme environment introduces its own combination of thermal, mechanical, chemical or operational challenges. There is no universal solution.

Successful actuator engineering depends on understanding how each environmental factor influences individual components, then adapting the complete electromechanical system accordingly.

Whether protecting against freezing temperatures, intense heat, underwater operation, explosive atmospheres, nuclear radiation or military shock loading, the objective remains the same: delivering reliable valve operation precisely when it matters most.

As critical infrastructure becomes more demanding and operational resilience becomes increasingly important, actuator selection is no longer simply about torque and speed. It is about engineering confidence into systems expected to perform in the harshest environments imaginable.



For engineers specifying valve automation, that means choosing solutions that have been designed, configured and proven for the environment in which they will ultimately operate, not simply for the valve they are intended to drive."

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