

Closed-Loop Proportional Control

Why Proven Technology

Continues Leading



How the 4WREE valve family delivers repeatable

accuracy through integrated feedback and robust design

Proportional valve technology has evolved significantly since early open-loop designs emerged decades ago. Yet fundamental requirements—accurate flow control, repeatable performance, and reliable operation in demanding conditions—remain remarkably constant.

The 4WREE proportional directional valve addresses these requirements through closed-loop control architecture refined across millions of installations spanning diverse industries. This whitepaper examines why this approach continues serving applications where proportional control determines product quality and overall system performance.

KEY CHARACTERISTICS

- Closed-loop position feedback for repeatable accuracy
- Rugged construction for demanding industrial and mobile environments
- Improved electronics enabling modern system integration
- Proven reliability across diverse applications

UNDERSTANDING CLOSED-LOOP CONTROL

The Open-Loop Limitation

Early proportional valves operated open-loop: electrical input commanded spool position, but nothing verified the spool actually reached or maintained that position. Flow forces, friction variations, and temperature effects all introduced errors between commanded and actual positions.

For applications with wider tolerances, these errors remained acceptable. For precision applications— injection molding, material testing, synchronized motion—they created quality problems and process variability that showed up in rejected parts.



Closed-Loop Solution

The 4WREE integrates position feedback directly into valve design. An electronic module continuously compares commanded position to actual position and corrects any deviation instantly.

The control sequence:

- Control signal commands a spool position
- Position sensor (LVDT) measures actual spool location
- Electronics compare commanded versus actual position
- Correction current adjusts to eliminate error
- Spool reaches and maintains exact commanded position

This process operates continuously ensuring accuracy regardless of changing operating conditions surrounding the valve.

ACCURACY IN PRACTICE

What Accuracy Actually Encompasses

Valve datasheets specify accuracy as a percentage—typically less than 0.1% hysteresis for quality proportional valves. But practical accuracy includes multiple factors working together:

What does standardization deliver?

- **Position Accuracy:** How closely actual spool position matches commanded position. Closed-loop feedback makes this primarily limited by sensor resolution rather than hydraulic variables.
- **Linearity:** How consistently the valve responds across its operating range. A linear valve requires minimal compensation in control programming—a 50% command produces exactly 50% flow whether starting from 0% or transitioning from 100%.
- **Hysteresis:** The difference in response when approaching a position from opposite directions. Low hysteresis (less than 0.1% for 4WREE) eliminates “dead zones” where small command changes produce no system response.
- **Repeatability:** How consistently the valve returns to the same position for identical commands across multiple cycles spanning days or weeks. This determines whether your process produces consistent results.

The 4WREE’s closed-loop design optimizes all four characteristics simultaneously. Position feedback eliminates variables causing non-linearity and hysteresis in open-loop designs.

TROUBLESHOOTING CLARITY

When system performance deviates from expected behavior, feedback clarifies diagnosis through actual data:

- **Position feedback shows:** Is the spool reaching commanded positions?
- **Current monitoring indicates:** Are the solenoids drawing expected power?
- **Response time reveals:** Are there mechanical binding or contamination issues developing?

These data points guide systematic troubleshooting rather than requiring guesswork. Problems trace to identifiable causes with clear solutions rather than mysterious symptoms requiring extensive investigation.

ROBUST CONSTRUCTION FOR REAL-WORLD CONDITIONS

Environmental Challenges

Laboratory test conditions and production environments differ significantly. The 4WREE prioritizes the latter, where real installations face challenges including:

Robust spool guidance maintains alignment under shock loads and side forces. Industrial presses generate impact loads during cycles. The spool must maintain precise positioning despite these forces.

Protected electronics survive moisture, electrical noise, and thermal extremes. Enclosure design and component selection ensure integrated electronics function reliably in machinery environments rather than requiring climate-controlled conditions.

IMPROVED ELECTRONICS INTEGRATION

Maintaining Core Performance While Advancing Connectivity

The 4WREE's fundamental hydraulic and control architecture remains proven technology validated across decades of field operation. Current generations add electronic capabilities addressing modern integration requirements without compromising reliability:

Robust EMC compliance (tested to EN 61000-6-2 and EN 61000-6-3 standards) ensures reliable operation in electrically noisy environments without elaborate shielding requirements.

Protection features including undervoltage detection and cable break monitoring (on current interfaces) prevent unsafe operation under fault conditions that could damage equipment.

These improvements enable the valve to integrate with contemporary control systems while maintaining the reliable performance characteristics establishing its reputation over previous generations.



APPLICATION VERSATILITY

Proportional valve technology continues advancing, but fundamental requirements remain constant: accurate control, repeatable performance, robust construction, and straightforward application enabling predictable project execution.

The 4WREE proportional directional valve addresses these requirements through design choices prioritizing real-world reliability over theoretical peak performance. Closed-loop position feedback ensures accuracy. Fast response simplifies commissioning. Rugged construction handles demanding conditions. Improved electronics enable modern integration.

The result: a valve appearing repeatedly on specification lists because it solves problems reliably—the practical definition of “frequently desired” in industrial equipment markets.

For detailed technical specifications, selection guidance, or application consultation, contact Bosch Rexroth Industrial Hydraulics.

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