

The image shows a large industrial facility, likely a CO2 pipeline, with several large grey pipes and blue Rotork valves. The valves are mounted on the pipes, and the background is a clear blue sky. The overall scene is industrial and technical.

rotork[®]

Keeping the World Flowing
for Future Generations

Helping tackle CO₂ transportation challenges

Flow control solutions for next-generation CO₂ pipelines

Carbon capture and CO₂ transportation

Carbon dioxide (CO₂) can be transported using pipelines, roads, railways, or ships. The choice of transportation depends on factors such as volume, distance, geography, regulations, and the specific use of the CO₂. Pipelines are preferred when transporting large amounts of CO₂ over long distances because they are cost-effective.

What do we mean by next-generation CO₂ pipelines?

In traditional Carbon Capture and Storage (CCS) projects, CO₂ is collected from a single source and transported via high-pressure pipeline to the storage location. Next-generation CO₂ pipelines, however, will use both low-pressure (gas phase) and high-pressure (dense phase) networks which are more complex. This combination allows for safe transportation of the CO₂, including where pipelines are close to populated areas.

Future CCS networks are expected to take the form of 'hubs'. CCS hubs are shared infrastructure for collecting and storing CO₂. The hub approach is designed to accelerate commercialisation by lowering investment risks and is attracting Government support. Hubs enable industries in the same area (the 'cluster') to jointly tackle their carbon emissions.

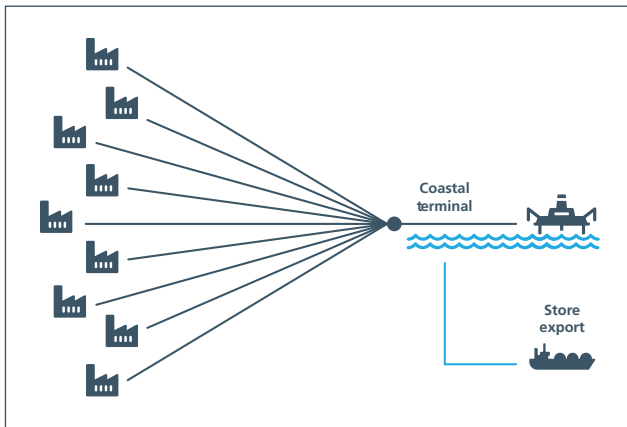
The Oil & Gas Climate Initiative (OGCI) sees great potential for CCS hubs. They estimate that hubs could reduce CO₂ emissions by 933 million tons annually, around 2% of total global emissions.



The different scenarios of next-generation CO₂ pipelines

Rotork's intelligent flow control solutions have an essential role to play in each of the three scenarios presented below. The following explanations illustrate the different scenarios using research and data from the University of Strathclyde Centre for Energy Policy.

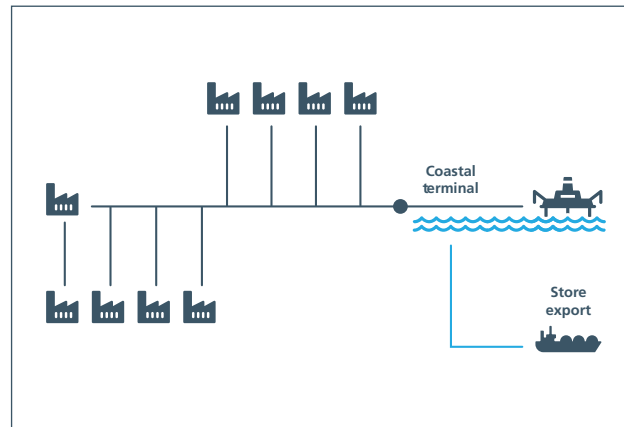
Scenario 1 design: Each to their own



In this scenario, each CO₂ emitter builds a separate onshore pipeline to the storage facility:

- This is the most expensive option and is considered impractical due to the size of the infrastructure required - permissions and rights of way would need to be acquired
- Considered the least risky option, as every emitter will be responsible for the quality of their CO₂ and pipeline operation (ref BEISS UK Business Model Contract Risks)
- The offshore infrastructure is considered to be shared. It is not feasible, due to pipeline landfall restrictions, to have separate offshore pipelines in this context

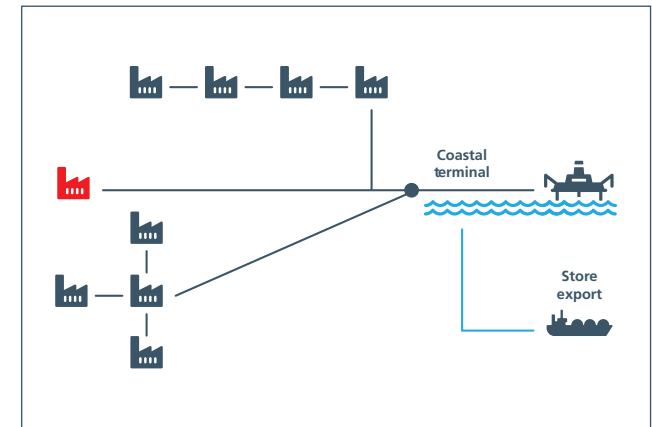
Scenario 2 design: Build it and they will come



In this scenario, there is a central pipeline into which all of the emitters feed:

- It is envisaged that each emitter will come onstream at different times, the main trunkline pipeline must be oversized to accommodate increasing demand
- The phasing of the entrants into the system is critical in terms of the operational efficiency of the network
- The risk in this option is that "they don't come," but this risk decreases with the drive to net zero
- The offshore part of the infrastructure is considered to be shared as per scenario 1

Scenario 3 design: Early adopter/collaborator



In this scenario, there is one early adopter (highlighted in red):

- There are then separate trunk lines to the source, but industries collaborate in a gathering network cluster to feed into that network
- This is a halfway house scenario between scenarios 1 and 2 and reduces the risk of the early adopter being left stranded with an oversized pipeline
- It will be potentially more expensive than scenario 2

Rotork and sustainability

Our leading ESG ratings

MSCI

AA

Leader

S&P Global CSA

Top 5%

Ranked in the top quintile in our industry globally

Sustainalytics

Top

Industry top rated

CDP Worldwide

CDP Climate: B
CDP Water Security: B



2022 performance across key sustainability metrics:

CO₂ emissions
(scopes 1 and 2)

-17%

Carbon emissions
(per £m revenue)

-21%

Electricity usage

-2%

Water usage

+6%

Sustainability commitment

Rotork is determined to help drive the transition to a cleaner future where environmental resources are used responsibly. The Group is committed to being a net-zero business by 2035 (by 2045 for scope 3).

Rotork's intelligent electric actuation solutions enable the decarbonisation of industrial processes through electrification and the use of renewable energy.

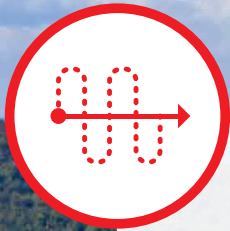
ESG ratings

S&P Global placed Rotork in the 95th percentile in the Machinery & Electrical Equipment industry in its 2022 Corporate Sustainability Assessment. Sustainalytics ranked Rotork 10th out of 416 companies in the industrial machinery sector.

Eco-transition portfolio

The eco-transition portfolio, consisting of Rotork's products and services which have particular environmental or sustainability benefits, comprises the Group's 'water & wastewater', 'methane emissions reduction', and 'new energies & technologies' portfolios.

Carbon capture is part of the new energies and technologies portfolio.



Delivering efficient and cost effective operations

For CO₂ pipeline hubs to be adopted globally, large and small-emitting industrial facilities need to cooperate (clusters) and efficiently supply the network with CO₂.

Next-generation hubs need to be efficient. CO₂ can be collected from multiple industries, enabling faster scale-up and lower transport costs.

Continue reading to understand how we can deliver intelligent and reliable CO₂ control, even in remote locations. Find out how we can support hubs and clusters in the efficient and cost-effective operation of their flow control assets.



Need:
More control

As clusters grow, the volume, flow, and pressure of CO₂ entering the hub will be complex to manage.

A small CO₂ pressure drop can cause a significant temperature reduction due to the large enthalpy gradient of CO₂ compared to most gases. There is a risk of a phase/state change, Joule-Thomson cooling, and expansion effects in the system.

A slight increase in CO₂ temperature can cause rapid pressure rises, which can cause excessive vibration if not controlled.

Solution

Skilmatic SI electro-hydraulic actuators have emergency shutdown (ESD) capability and provides configurable opening and closing times for flow control valves.

We also have bespoke modular electro-hydraulic products that provide the facility to tailor the solution to your specific needs if outside a standardised offer.

Need:
OPEX reduction

Carbon capture and storage facilities have historically had relatively high annual operating expenditure (OPEX).

Increasing efficiencies in all OPEX can be as simple as adopting the latest proven technologies.

Solution

Our electric and electro-hydraulic actuators benefit from low lifetime cost of ownership, with long 'mean time between repair' compared to alternatives. The IQ and Skilmatic SI actuators are 'sealed for life,' proven in the world's most remote and arduous environments.

The actuators have on-board data loggers, so when hubs add new customers to their system. The data logger can record up to 3,000 events, providing a comprehensive record of valve performance. This data can be sent to Rotork's Intelligent Asset Management (IAM) cloud-based system which provides predictive insights to prevent unplanned downtime.

Need:
Remote operation, low power usage

Hub pipelines will collect CO₂ from multiple clusters, many pipeline 'block' valves will be needed, strategically located, to reduce risk in case of a pipeline rupture.

This risk presents additional costs, where flexibility to install a simple and effective valve automation solution could save significant costs.

Solution

The IQ and Skilmatic SI actuators are suitable for low-power remote operation. SI actuators can be used where solar power and battery storage is available, and IQ-D (direct current) actuators feature circuitry to reduce power consumption during periods of non-valve operation. These actuators enable an innovative, simple, standardised solution where construction and commissioning plans can be more predictable and efficient.

CP and GP pneumatic actuators provide an efficient option when pre-existing instrument air supply (including conventional utilities) is available.

Rotork solutions for delivering efficiency

Skilmatic SI spring-return electro-hydraulic actuators



Self-contained actuators for ROSoV valve operation and intelligent diagnostics

Safety and ESD shutdown capabilities

- Provide fail-safe actuation for ESD applications
- Fast shut-down response protects your investments
- SIL 2/3 compliant for use in SIS to IEC 61508
- Partial Stroke Testing (PST) capability
- Integral interrupter timer eliminates risk of water hammer effect during emergency valve closure
- Designed to meet today's control and safety needs
- Double-sealing design reduces affects of humidity, improves reliability and reduces downtime
- In-built data logger provides trend analysis and diagnostic data for asset management and analytics

IQT part-turn electric actuators



Heavy-duty pipeline valve control and intelligent diagnostics

Reliability and diagnostics

- Accurate, reliable and safe actuation of multiple valve types throughout CO₂ hubs/clusters
- Proven in remote locations throughout the world, requiring minimal maintenance
- Robust and reliable isolation duty
- Compact size, low weight, high power output
- Up to SIL 2 capability to IEC 61508
- Low power variants for DC solar power supply
- Double-sealing design reduces affects of humidity, improves reliability and reduces downtime
- In-built data logger provides trend analysis and diagnostic data for asset management and analytics

IQD multi-turn direct current (DC) electric actuators



Heavy-duty pipeline valve control and intelligent diagnostics

Reliability and diagnostics

- Low inertia rotors
- Incorporates sleep circuit for power reduction when used on solar power derived DC supplies
- High stall torque in comparison with that required to operate and seat the valve, essential in maintaining the rated torque at reduced voltage conditions
- Inclusive lost motion drive (hammerblow), allows the motor to reach full speed with maximum available torque before the drive is applied to the valve
- Meets the requirements of EN15714-2 (electric actuators) and complies with IEC60034 and NEMA MG1
- Double-sealing design reduces affects of humidity, improves reliability and reduces downtime
- In-built data logger provides trend analysis and diagnostic data for asset management and analytics



Reducing risk in CCS projects

The hub and cluster approach reduces costs and risks for many potential CCS projects. They remove the interdependency between the size of individual emitters, their investment decision, and the scale of the related storage/transport development.

The IEA Greenhouse Gas (IEAGHG) review argues that the main risk for clusters is commercial rather than technical in nature but also raises five technical challenges, including scaling up and project management. Scaling-up issues include managing filling rates and extensive use of automatic emergency block valves, especially when the pipelines carry large volumes of supercritical CO₂. The balance between central and decentralised control of the CCS hub will need to be met, with the independently managed parts of the enterprise having good coordination.

(IEA Greenhouse Gas R&D Programme, 2015. Carbon capture and storage cluster projects: review and future opportunities, London: IEAGHG).

We can provide certainty of automation and help operators maintain single-phase/state CO₂ control between defined points.

Need:

Rapid protection from pressure deviations

CO₂ can be transported in different states, and if this state changes (e.g. from liquid to gas), it can damage the equipment infrastructure. Large amounts of CO₂ may need to be removed in a safe and controlled manner. Keeping CO₂ in a stable single state between primary pumps or compressors will help control the pipeline's integrity.

CO₂ has a large enthalpy gradient. Detecting pipeline pressure changes and making adjustments locally will significantly benefit the pipeline integrity.

Solution

An ELB (Electronic Line Break) can work with the Skilmatic SI actuator to provide early detection of pressure changes, allowing the system to react quickly to pressure deviations due to the challenges of balancing supply and demand of the pipelines.

Need:

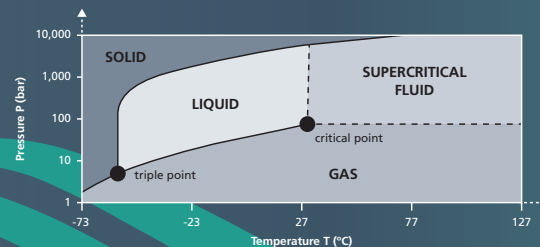
Keeping CO₂ in a single state

Controlling valve closing speeds helps to ensure no water/fluid hammer occurs. Hubs will have multiple filler and injection points, so reliable and controlled valve operation will be critical. Stopping pressure surges from water/fluid hammer will protect assets from unnecessary vibration. Early detection of pressure changes will be essential to keep CO₂ in the required phase state, maintaining pressure and temperature where possible.

Solution

IQ and Skilmatic SI actuators can adjust opening and closing times to adapt solutions as the hub/cluster evolves, future-proofing the system and avoiding future OPEX expenditure.

SI actuators with an ELB can provide early detection of pressure changes. ELB is a proven solution for detecting pressure threshold changes in remote locations along pipelines.



Above is a CO₂ phase diagram, reminding people of the challenges to keep CO₂ in its same state during pipeline transportation.

Need:

Remote location, standardisation, and faultless sporadic operation

As de-pressurised CO₂ tends to slump, it is essential to have automated valves close to high-risk areas in case of a pipeline rupture.

Standardising valve opening and closing times in relation to cluster demands must be determined from the early clusters and hubs being built.

Operation on demand is essential, including when actuators have not been used for long periods.

Condition of valve stem seals is of safety importance for engineers entering valve pits for maintenance*.

Solution

The IQ actuator hammer-blow feature could help if dry ice forms inside valves. Skilmatic SI's ESD capability and configurable opening and closing times could add real value to operating CO₂ pipeline valves.

IQ and SI actuator data loggers enable predictive maintenance of critical valves, which can provide early warnings and corrective actions. In remote unsecured locations, they are designed to withstand interference and have the option to add extra security such as vandal proof covers.

* IPCC special report on CO₂ (2005), illustrated 10% of CO₂ pipeline USA incidents between 1990 and 2002, were due to valve stem seal packing failure.

Rotork solutions for reducing risk

IQ actuator with IW part-turn gearbox



Intelligent valve control to eliminate hammerblow effect

Secure flow control for high pressure and torque valves

- IQ actuator hammerblow feature could help if dry ice forms inside valves
- IW mk2 worm gear operators are quarter-turn devices intended for motorised operation of ball, plug and butterfly valves
- Gearboxes include low lead angle gearing designed to be inherently self-locking
- Datalogger monitoring of valve performance, preventing unwanted shutdowns
- Up to SIL 2 capability to EN61508
- Can be configured for different types of valves

Skilmatic SI actuator with Electronic Line Break (ELB)

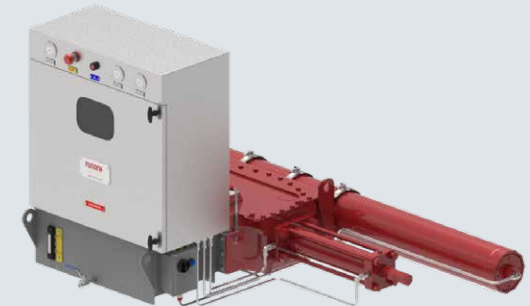


Pipeline pressure monitoring and emergency valve control

Pipeline pressure monitoring system

- Rotork's ELB system is designed to continuously monitor pipeline pressure and provide automatic valve actuator movement to an emergency position
- Comprehensive data logging in non-volatile memory with real-time clock
- Manual reset option to maintain Process Shutdown (PSD) position until human intervention allows a return to normal operation
- Pressure monitoring with Rate of Drop (RoD) and Rate of Rise (RoR) calculation
- Configurable process shutdown position (PSD) to open, close, or stayput
- Will operate on 9-28 VDC supply voltage
- Certified IP66/IP68 and NEMA 4, 4X & 6

Bespoke modular electro-hydraulic actuators



Tailoring electro-hydraulic to your unique needs

Onshore and offshore on/off, ESD valves

- Combines the simplicity of electrical operation with the high torque/thrust and fast action capabilities of hydraulic high pressure control
- Self-contained with reduced piping and built-in hydraulic power source reduces transit damages, installation costs and oil leak risks
- Partial stroke, full stroke, fail-safe or fail last operation
- Zero emission
- Accumulator ensures pressure back up to keep the system under pressure
- Ability to consider low-power infrastructure (including solar) – for standby and operational
- Designed to meet customer certification requirements, including Safety Integrity Level up to SIL 3



Optimising CCS hub operations

Strong policy support and cooperation between potential participants are needed to develop hubs and clusters.

The IEAGHG (2015:93) stated that one of the technical challenges foreseen with CCS hubs is 'process and system control and optimisation.' The need for a network to cater to capacity variations is at the heart of this challenge, where the ability to optimise the operation of the entire hub and cluster system would have commercial advantages when change occurs over time.

The more cooperative customers are within the cluster system, the greater the potential for commercial gains of the operation. To get to the optimised end goal, various uncertainties exist. Reliability, flexibility, and data will be critical in effectively operating a hub and cluster system.

The first project to optimise the CCS hub/cluster model will be able to apply their knowledge globally.

Need:

Monitoring and diagnostics to reduce uncertainty and increase visibility

The first hub and cluster projects have the opportunity to be innovators for future designs. To optimise and reduce valve redundancy over time, efficiencies will be gained through obtaining and analysing data. Working in CO₂ clusters has many uncertainties, primarily as the system relies on people collaborating to fill and discharge the CO₂ hub network. The CO₂ hub and cluster market currently has many known and unknown challenges.

Solution

IQ and Skilmatic SI actuators have onboard data loggers to provide information on operational vibration and temperature trends, valve torque profiles, start profiles, and an event log. As the future CCS market will likely embrace digital communication and control, installing intelligent actuators at the beginning will help reduce upgrade costs. The CO₂ hubs/clusters that optimise first will be able to share their expertise globally.

Need:

Proven reliability and robustness, when faced with all challenges

As the IEAGHG (2015) highlighted, good coordination between customers and stakeholders is critical to optimising the system. Effective centralised (hub) and decentralised (cluster or site) control is essential in the early stages to ensure a reliable flow of CO₂ is established. Proven, robust valve actuation and optimised tank farm control will be necessary when the project is first established, as co-ordinating best practices take time to develop.

Solution

The Rotork *Master Station* is an industry-proven supervisory control system that reliably and robustly communicates from the Distributed Control System (DCS) to the devices in the field. Rotork's *Pakscan*[™] field network technology can monitor and control up to 240 devices over a simple, cost-effective 2-wire loop of up to 20 km. This solution could offer the right control network to regulate CO₂ flow from the cluster into the hub effectively.

Need:

Contingency to adjust opening and closing times (optimise performance)

CO₂ hub/cluster pipelines will likely be intentionally oversized to service new customers. Early hub/cluster projects will provide the knowledge to optimise others.

They must obtain as much data from their system as possible to adapt and adjust to accommodate future demands and scenarios. Valves will benefit from having the flexibility and contingency to change with operations over time.

Solution

Skilmatic SI actuators meet ESD application specifications that require valve actuators to deliver fast and controlled fail-safe operation. The SI also has the ability to configure valve opening and closing times as the CO₂ cluster grows with new customers. The SI uses a simple and reliable mechanical spring for valve closure operation and features internal flow control valves to adjust the closure speed. Control in the opposite direction is achieved hydraulically using an adjustable integral electric pump. The robust nature of all these features in a self-contained unit provides certainty for potential future needs.

Rotork solutions for optimisation

Skilmatic SI spring-return electro-hydraulic actuators



Multiple speed control options as standard

In-built multiple speed options

- Optional mechanical speed control in the spring direction, through fixed adjustable valves on the module
- Operating speed in the hydraulic direction is controlled using a stepping function in the actuator settings
- SI accumulator includes a mechanical speed control valve option
- In-built alarms to indicate and report process and control anomalies back to the control room

Network control systems



Pakscan™



HART
COMMUNICATION PROTOCOL

DeviceNet



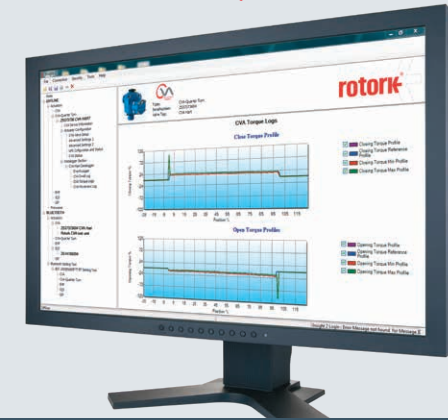
Modbus®

Valve control and monitoring

Reliable network control with reduced cabling complexity

- Multiple options available for control and communication between the PLC and actuators
- From simple, effective hard-wired digital control, to variable 4-20 mA and high-end digital networks with options including Profibus®, Modbus®, Foundation Fieldbus® and Rotork's proprietary Pakscan™ network
- Network options reduce the need for multiple cable runs
- Minimised cabling costs
- Maintained integrity

Insight 2 software



Actuator analysis and configuration

Intelligent data logger analysis and actuator configuration

- Review, configure and analyse set-up configuration and data logger information from Rotork actuators
- View and modify actuator specification and configuration on PC
- Valve and actuator starts against position log
- Valve torque profile, open/closed instantaneous and average torque against valve position
- View and modify option card configuration
- Operation and actuator control status log
- Pre-configure missions on PC and transfer them to actuators in the field via the Rotork Bluetooth® Setting Tool Pro



Other solutions for next-generation CO₂ pipelines

Rotork is a market-leading global provider of mission-critical intelligent flow control solutions for industrial and flow control markets.

We have a long history of research and development activities to ensure innovative solutions are available for every application as we solve customers' challenges. Our flexibility allows us to develop new solutions to create successful and reliable operations.

Reducing risks, delivering efficiency, and optimising needs and solutions only touched on so far are now given focus.



Other Rotork solutions

CVA and CMA part-turn and linear electric control valve actuators



High precision control valve operation

Accuracy and repeatable performance

- Reliable high definition linear, quarter-turn and rotary valve operation
- Precise actuation of control valves involved in the pressure and flow control process
- Compact and powerful, with a 0.1% resolution capability
- Maintains tight process specifications
- Reduces measurement uncertainty
- Internal fail-safe super-capacitors on some models

Remote Hand Station (RHS)



Remote field operation for IQ and SI actuators

Operator safety for valves in hard to access locations

- Enables remote configuration, interrogation and operation of the connected actuator up to 100m from the valve installation
- Pole or wall mountable
- Replica of the actuator user interface, including setup and configuration
- Powered via the attached actuator (24 VDC output)
- Enclosure IP66 / IP68 (7 m for 72 hours)
- Double-sealed
- Asset management and data log information available to view or extract locally

Vandalism protection



Secure protection against vandalism and malpractice in remote locations

Security and safe remote operation

- Vandalism / malpractice protection options for remote sites
- Lockable cover protects standard selectors and window
- Actuator can be controlled via remote inputs only
- Setup options include the ability to disable local controls and setting tool input
- Rotork App control available if all local controls removed

Other Rotork solutions

InMax part-turn electric valve actuators

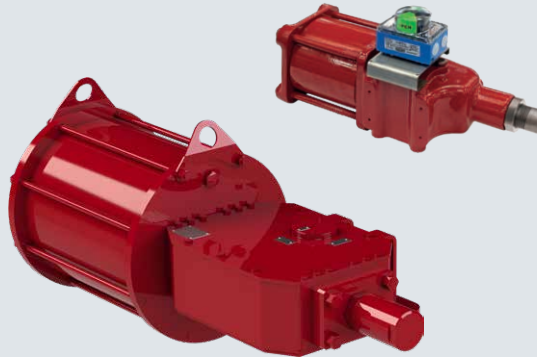


Compact, robust actuation of auxilliary valves

Accuracy and repeatable performance

- Reliable linear, quarter-turn and rotary valve operation
- 24-240 VAC/VDC auto-adjustable power supply suitable for solar power operation
- Suitable for outdoor use with standard IP66 dust and waterproof enclosure
- Spring-return fail-safe option
- For automation of air dampers, fire and smoke dampers, volume control, ball valves and throttle valves

CP and GP part-turn pneumatic actuators



Reliable actuation across all compressor station pipeline applications

Safety, reliability and ESD capabilities

- Installed for safe isolation of compressor station main inlet and outlet pipelines
- Added security available with spring-return functionality providing automatic closure on air pressure loss or ESD event
- Mid-sized CP actuators used for moderate torques and for main line isolation (designed for ESD operation)
- GP actuators are used for high torque operation of larger valves

Bespoke anti-surge actuators and control systems



Modulating actuation of high accuracy, high speed anti-surge valves

Modulating duty for safety and reliability

- Integrated solution includes actuator, controller and pneumatic circuit
- High accuracy modulating valve control
- Accuracy, 0.5% end deviation on target position
- Max overshoot $\leq 5\%$
- Sensitivity up to 0.5%
- High speed operation achieving ESD in under 1 sec
- Stability throughout input frequency range
- Fast reaction times according to input signal with a low deadband
- Protects pipeline compressor from CO₂ transient conditions risk

Why Rotork?

Enabling a sustainable future

Rotork was founded in the 1950s with the invention of the modern-day electric valve actuator.

We have continued to break boundaries with electric valve actuation. At the same time, we have expanded our portfolio to include electro-hydraulic, hydraulic, pneumatic and instrumentation solutions.

Enabling a sustainable future is integral to everything we do, and our purpose of "keeping the world flowing for future generations" is core to all our development and innovation.

As next-generation CCS technologies emerge, we are well-positioned to provide the solutions for tomorrow's needs – today.

Challenging traditional mindsets

We are here to support your needs, to think differently, and to enable your developing technologies to become more efficient, optimised, and reduce risk.

We are a market-leading electric actuator manufacturer, and we have enabled customers to challenge the status quo in valve control. Today, we are helping customers transition from traditional pneumatic systems to electric solutions, which results in lower costs and greater digital capabilities.

If your company wants to think differently and challenge the traditional mindset, then we are here to support you as we have done so for over 60 years. If you want greater flexibility and lower costs, reach out to us. We are here to support you in your aspirations.

rotork® Site Services

Our service engineers work with industrial partners to design, update and maintain their plant and equipment.

Rotork's Site Services offers specialist expertise and insight into the maintenance of mission-critical flow control equipment. We offer global frontline support backed by dedicated in-house experts.

Our services increase plant efficiency and reduce maintenance costs, while workshop services return equipment to as-new condition. Our experience and understanding of the flow control industry means we have extensive insight and ideas of what we can do to provide significant value to our customers and their operations.

We deliver our site service products, with a variety of unique features that set us apart. On the next page, we list some of the most valuable services we provide.

Find out more, and download our brochure at www.rotork.com/en/services-support/site-services



Field support

- Maintenance planning and scheduling
- Site repairs and commissioning
- Upgrades



Actuator workshop overhaul

- Rotork and non-Rotork products
- OEM certified workshop facilities
- Large OEM spares stock in all workshops



Valve automation services

- Correct product selection to suit the process demands
- System integration
- Power supplies, motor control centres, etc.



Lifetime management

- Increased uptime/reduced downtime
- Maximised productivity
- Reduced operational risk



iAM report (Intelligent Asset Management)

- Predictive diagnostics with actionable insights
- Annual report gives snap-shot of asset(s) condition
- Quarterly reports give rolling view of asset(s) condition



Parts

- Genuine Rotork OEM parts
- Global availability
- Protect original build specification/certification



A full listing of our worldwide sales and service network is available on our website: www.rotork.com

