

rotork®

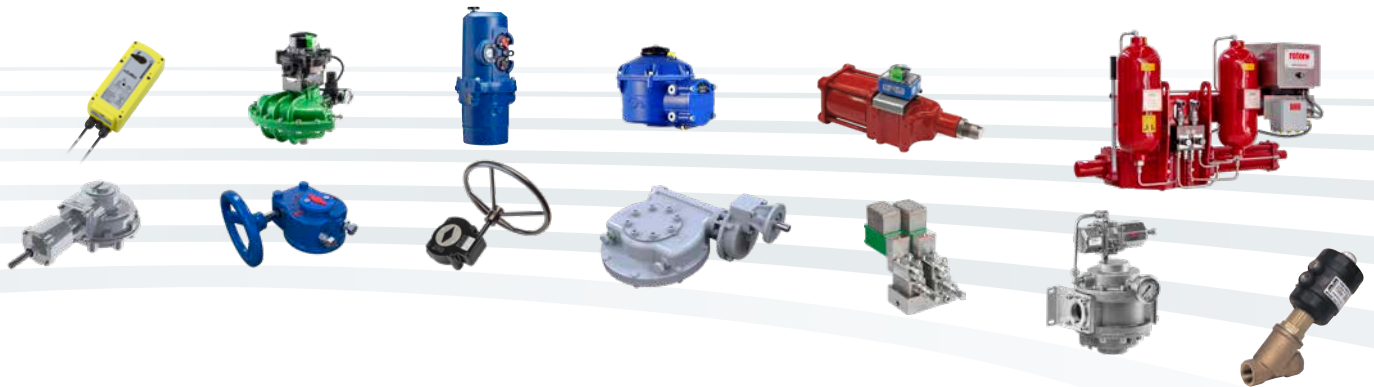
Keeping the World Flowing
for Future Generations

LNG Applications



Liquefied Natural Gas (LNG) Industry

Reliability in critical flow control applications



› Reliable operation when it matters

Assured reliability for critical applications and environments. Whether used infrequently or continuously, Rotork products will operate reliably and efficiently.

› Quality-driven global manufacturing

We offer products that have been designed with over 60 years of industry and application knowledge.

Our research and development ensures cutting edge products are available for multiple applications across multiple industries.

› Customer focused service and worldwide support

Rotork solve customer challenges and develop new solutions that are tailored to the needs of our clients.

We offer dedicated, expert service and support from initial inquiry, to product installation, to long term after sales care.

› Low cost of ownership

Long-term reliability prolongs service life.

Rotork helps to reduce long term cost of ownership and provides greater efficiency to process and plant.

LNG Applications

Section	Page	Section	Page
Introduction	4	LNG Process	8
Liquified Natural Gas (LNG) Industry	5	Exploration and Production	8
Examples of flow control products used in LNG import terminals	6	Liquefaction	9
		Storage	9
		Shipping	10
		Regasification and Delivery	11
		Rotork ROSoV Solutions	12
		Rotork SIL Solutions	13
		Site Services	14



Comprehensive product range serving multiple industries

Rotork products offer improved efficiency, assured safety and environmental protection across sectors such as the Power, Oil & Gas, Water & Wastewater, HVAC, Marine, Mining, Pulp & Paper, Food & Beverage, Pharmaceutical and Chemical sectors.

Market leaders and technical innovators

We have been the recognised market leader in flow control for over 60 years.

Our customers rely upon Rotork for innovative solutions to safely manage the flow of liquids, gases and powders.

Global presence, local service

We are a global company with local support.

Manufacturing sites, service centres and sales offices throughout the world provide unrivalled customer services, fast delivery and ongoing, accessible support.

Corporate social responsibility is at the heart of our business

We are socially, ethically and environmentally responsible and committed to embedding CSR across all our processes and ways of working.

Introduction



Rotork is a market-leading global provider of mission-critical flow control and instrumentation solutions for oil and gas, water and wastewater, power, chemical, process and industrial applications. We help customers around the world to increase operational efficiency, reduce environmental impacts, improve product quality and provide safer working environments.

Our comprehensive product portfolio and global service capability coupled with over 60 years of industry knowledge means customers can rely on us to understand the problems they face and to deliver reliable, economic solutions.

The innovative research and development activities across Rotork ensure cutting edge products are available for every application, as we solve customer challenges and develop new solutions to create successful and reliable operations.

Rotork has a number of policies in place to help us reduce our environmental impact with a particular focus on energy reduction and managing environmental emissions.

We are committed to the prevention of pollution and comply with legal and regulatory requirements. We reduce our environmental impact by targeting key areas such as energy consumption, water consumption and waste.

Knowledge

Since 1957 Rotork has operated across global markets, delivering intelligent flow control solutions for a wide-ranging suite of industries and market applications.

Quality

Rotork products are designed and built with quality components and clear user interfaces for quick and safe operation in the field.

Reliability

Rotork's rigorous product development and testing ensures long-lasting performance and continued reliability.

Innovation

Through a culture of continual improvement, we ensure our products remain at the cutting edge for every application, providing cost effective and environmentally friendly solutions.

Support

Our global network of local service centres and engineers is unrivalled in the flow control market.

Liquefied Natural Gas (LNG) Industry



In many countries natural gas has become a preferred fuel for power generation and growing demand cannot be satisfied by existing local sourced production.

LNG is increasing in importance as the demand for gas grows around the world and large quantities of gas have to be transported. Rotork is helping the LNG industry to meet these ever increasing demands.

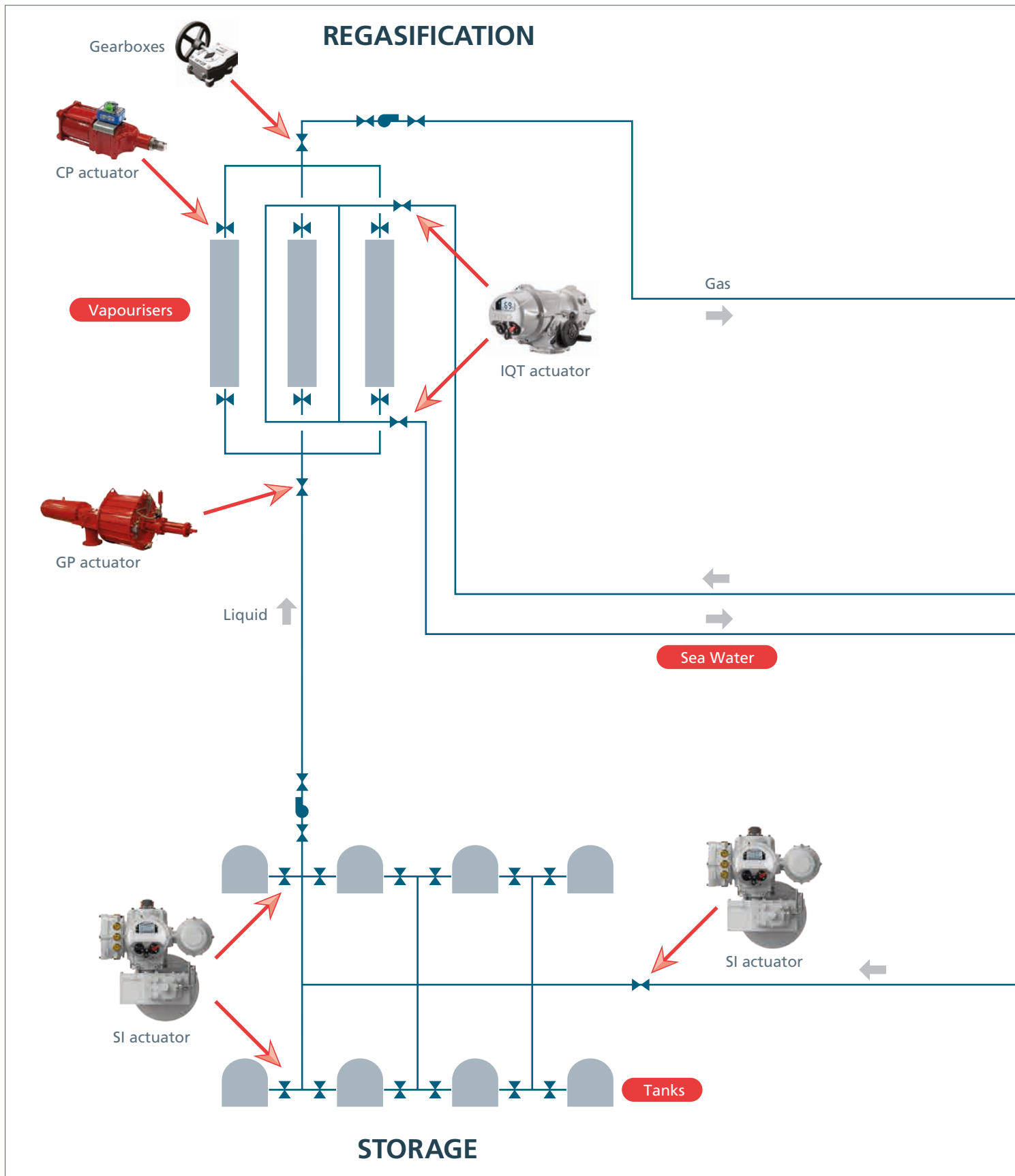
When it is impractical or uneconomic to use pipelines, large volumes of natural gas can be moved from source to market in liquid form. When cooled to $-162\text{ }^{\circ}\text{C}$, natural gas becomes a clear, colourless liquid and is commonly referred to as LNG.

Storage and transportation of LNG requires in-depth management and control. The extreme cold temperatures involved necessitate the use of cryogenically safe valves and associated top works. Safety and reliability of plant and equipment are therefore of paramount importance.

The LNG supply chain is complex and highly technical, involving the extraction and liquefaction, shipment on special tankers and regasification at import terminals.

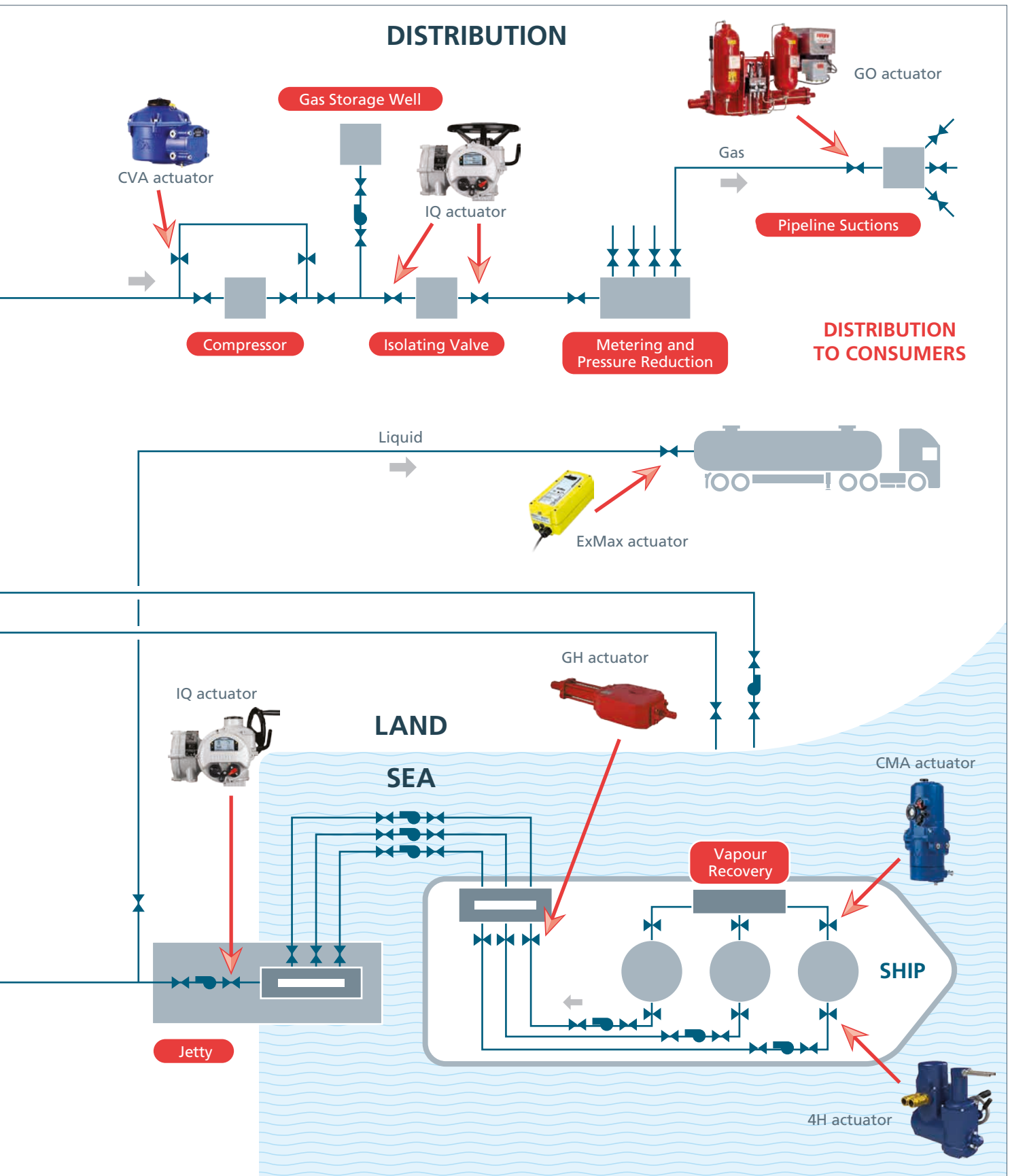
Rotork has been active in all sectors of the LNG process for over 30 years and continues to innovate in this field. Our flow control products are being specified for use on the latest FLNG vessels and are contributing to the increased efficiency and reliability of LNG plants all around the world.

Examples of flow control products used in LNG import terminals



The actuators are shown for indication purposes only and are not limited to these applications

DISTRIBUTION



LNG – Exploration and Production

Natural gas is formed when deposits of buried plants and animals are subjected to extreme heat and pressure over thousands of years. The gas is then trapped within fine pores of rocks. The depth at which the natural gas is located can vary from one to several kilometers.

After extensive geological exploration is completed and gas deposits have been identified, the natural gas is extracted from the subsurface using specially drilled wells called producing or operating wells.

A gas inlet stations received the raw gas, which is then treated to remove impurities such as hydrogen sulfide, helium, carbon dioxide, hydrocarbons, and moisture. The incoming gas is then metered and transported to the liquefaction plant for distribution.

Production applications where Rotork products are currently implemented:

- Wellhead Choke Valves
- Wellhead Isolation Valves
- Emergency Shutdown Valves
- Metering Isolation Valves
- Control Valves

The next generation of LNG production, Floating LNG (FLNG) facilities, are already being constructed. This new technology will help unlock new resources of natural gas by turning it to liquid at sea.

Floating above an offshore natural gas field, the FLNG facility will produce, liquefy, store and transfer LNG at sea before carriers ship it directly to markets.



Rotork Case Study

Rotork has been involved with LNG production for over 20 years. Our experience with exploration and production facilities in other industries has brought a wealth of knowledge to LNG production applications.

Companies within the Rotork Group work together to fulfill customer requirements on large LNG projects. Rotork has the ability to react quickly in locations throughout the globe, meaning that we often deliver solutions ahead of schedule which enables projects to be completed early and for production to begin.

Rotork Fluid Systems has supplied nine huge pneumatic actuators to operate ISO Class 900 16 inch and 36 inch ball valves at an LNG production plant in Australia.

The GP350 model scotch-yoke actuators have been installed on the onshore LNG production plant attached to the Pluto and Xena offshore gas fields, located in the Carnarvon Basin, north-west of Karratha in Western Australia. A 36 inch trunkline brings gas to shore from five subsea wells, where it is dehydrated, treated and undergoes liquefaction at a production rate of 4.3 mtpa.

The GP350 order was one of a number received by companies in the Rotork Group for the Pluto offshore and onshore facilities, encompassing fluid power and electric valve actuators.



LNG – Liquefaction

LNG is produced by a thermodynamic process called liquefaction. When cooled to -160 °C, liquified natural gas occupies 600 times less space than natural gas in its gaseous state. The final cooling to about -162 °C is accomplished by flashing the gas through a valve to just above atmospheric pressure. Storage tank pressure is maintained just above atmospheric pressure.

Every LNG plant is unique and a plant may have several liquefaction trains.

All valves down-stream from a train have to be a cryogenically safe type, operating at -162 °C. Cryogenic valves are available in all of the major valve configuration including ball, butterfly, gate and globe types and can be controlled by Rotork products.

Liquefaction applications where Rotork products are currently implemented:

- Gas Intake Regulated Ball Valves
- Cryogenic On/Off Ball Valves
- Cryogenic Butterfly Valves
- Cryogenic Globe Valves
- Emergency Shutdown Valves

LNG – Storage

LNG liquid storage tanks are always doubled-wall, cylindrical, and with a domed roof. The LNG is stored as a “boiling cryogen” liquid, which stays cold if kept at constant pressure. Some LNG vapour from the top of the tanks is allowed to leave, and this keeps the temperature constant.

Storage applications where Rotork products are currently implemented:

- LNG Re-circulation System Valves
- Tank Cross Over Valves
- Jetty Tie In Valves
- Liquid Arm Ship Loading
- Liquid fill for tanks
- Tank Isolation Valves
- Tank Pumps Discharge Valves

Rotork actuators can be specified to include unique features that greatly help in LNG storage applications such as:

- Hardwired ESD System
- Fully Automated Control System - *Pakscan*
- Hardwired Position Indication

Rotork Case Study

Rotork flow control products have been selected for applications throughout the giant Queensland coal seam gas-to-LNG projects in Australia.

The three projects – Queensland Curtis LNG, Santos GLNG and Australia Pacific LNG - are developing coal seam gas in Queensland’s Surat and Bowen Basins. Hundreds of kilometres of pipelines will link the natural gas production wells on the Queensland mainland with a world-class LNG production plant under construction on Curtis Island, which will initially produce more than twenty seven million tonnes of LNG for export each year.

For the upstream mainland wellheads, HART-enabled Rotork CVA modulating electric actuators have been ordered for process valve control at an eventual total of 2000 widely distributed sites. In addition, nearly 1000 Rotork Skilmatic SI and EH range electro-hydraulic actuators have been ordered for control and shutdown valves on wellhead and metering skids. These self-contained actuators combine the simplicity and convenience of electrical operation with the reliability of mechanical failsafe motion, and were designed to SIL3 standards for use in safety critical applications,

The orders for Rotork electric actuators were completed with IQ actuators for various isolating valve automation duties.

Additional Rotork orders on this giant project involve fluid power actuators for the pipeline and the LNG plants on Curtis Island. The majority of these are CP and GP range pneumatic actuators operating butterfly valves on LNG production lines. The actuators are customised with control packages to meet specific operating duties, including SIL2 and SIL3 applications.

The remainder are GO range gas-over-oil actuators, most of which are for the large mainline pipeline shutdown valves. GO actuators are designed to use the pressure of the pipeline gas as the motive power source. Integral control functions facilitate a wide range of duties, usually safety related and including line break, low pressure close, high differential inhibit and ESD.



LNG – Shipping

LNG is shipped round the world on special refrigerated tankers. The LNG is loaded at -162 °C and kept at that temperature by maintaining the pressure. While the ships are in port empty, the temperature of the tanks is kept low by constantly spraying LNG. The pumping starts slowly, to cool the pipes. Then the tanks are sprayed with LNG before loading starts.

Worldwide, there are more than 400 carriers that transport LNG, with total cargos exceeding 230 million metric tonnes in 2013. These figures will continue to increase alongside new advances in exploration and production.

These transportation ships require actuation solutions not just for the management and control of the LNG cargo but also in the areas of ballast, bilge and other vessel systems.



Rotork Case Study

Hundreds of 4H multi-turn hydraulic actuators have been supplied to LNG vessels all around the world. On these vessels, the unique actuation properties of the 4H actuator successfully overcome many potential operational problems, particularly on the cryogenic globe valves used for cargo loading and unloading.

The high efficiency modulating actuators used for these duties are operated hydraulically, using a shipboard power supply with limited total capacity. This can directly influence the actual pressure in the system, depending on how many field units are in use at any given time. In some circumstances, actuators sized for an 80 Bar hydraulic supply pressure may be briefly subjected to pressures surges of up to 140 Bar, with the potential to cause catastrophic damage to the control valve as well as hazardous product leakage. These issues are eliminated by the torque limiting feature of the actuator's design, which through its Planetary Torque Control System (PTCS), incorporates a mechanism to permanently limit the torque output under any circumstances, even at high speeds.

Other important considerations include the compact and lightweight design. In our experience, a reduction in actuator weight from 150 to 60 kilograms and from 250 to 78 kilograms, with no reduction in the output torque, has been achieved on two typical marine applications. The consequential reduction to the actuator power input requirement as a result of adopting the 4H actuator amounted to 50-70% in comparison with conventional actuators.

The actuated valves for these applications are mounted on deck, where they are fully exposed to a highly corrosive marine environment, especially when in sea passage, so special paint treatment is applied to the IP67 or IP68 double-sealed watertight enclosures of these explosion-proof actuators.

In other applications the actuators are subjected to total submersion in seawater, often for long periods. In these cases, the duties performed by our hydraulically operated multi-turn actuators include ballast control, where they are fitted to valves installed inside bilges that are routinely filled with seawater.



LNG – Regasification and Delivery

Regasification usually occurs at a coastal import terminal. These terminals have very specialised requirements in the following areas to cater for the management and handling of the LNG:

- Ship docking
- Unloading
- Storage
- Heating
- Vapourisation

LNG regasification equipment consists of submerged combustion vapourisers where the LNG is warmed, and vapourisers where the pressure is reduced.

Valve actuation applications in import terminals include:

- Liquid arms unloading valves
- Liquid circulation
- Tank pump discharge
- Tank liquid fill
- Vapour discharge
- Liquid to vapouriser
- Vapour from vapouriser valves
- Water cooling circuit valves
- Gas outlet valves

The gas is compressed and then pumped along pipelines.

When the LNG import terminal is near to its destination the gas passes through metering and pressure reduction stations. It is then distributed by smaller pipelines to end-users including:

- Domestic
- Power plants
- Other chemical plants or industrial users



Rotork Case Study

Rotork fluid power valve actuators have been installed throughout a major LNG importing and distribution project that is expected to meet 40% of the demand for gas in Chile and secure energy independence for the country. The LNG complex at Quintero Bay encompasses the installation of a sea terminal to receive LNG from tankers and a plant for regasifying and distribution by pipelines. The Quintero Bay terminal will have an annual supply capacity of 2.5 million tons of LNG.

Rotork heavy duty, scotch-yoke pneumatic, gas-over-oil and high pressure gas actuators have been supplied to valvemakers in France, Italy and Spain. The majority of the eighty-seven CP and GP range pneumatic actuators supplied are operating cryogenic service ball and butterfly valves at the Quintero Bay marine terminal and the adjacent storage and regasification plant.

The GO range gas-over-oil and HPG range high pressure gas actuators have been supplied for a new 28 kilometre pipeline which links the Quintero LNG complex to the Electrogas terminal at Quillota for integration with the existing gas network and fuelling combined cycle power plants operated by Endesa Chile. The GO unit is installed on a Class 600 24 inch ball valve at the City Gate in the Quintero LNG terminal, whilst the HPGs are installed on Class 600 8 inch and Class 300 12 inch ball valves at the Electrogas Plant Gate in Quillota.

Designed for safety and shutdown duties, GO and HPG actuators use the pipeline gas as the motive power source. Valve operating speed is adjustable in both directions and manual hydraulic override is provided as standard. All the Rotork actuators supplied are certified to ATEX 94/9/EC and IP66M/67M in accordance with PED 93/27/EC.

The sales and engineering participation of Rotork's local representative in Chile, Ineco, S.p.A, has been a key factor in the company's success with this important project. Rotork's activity was co-ordinated at Rotork's USA head office in Rochester and involved Rotork offices in France, Italy, Spain and the UK.



Rotork ROSoV Solutions

Remotely Operated Shutoff Valves (ROSoV) are valves designed and installed for the purpose of quickly isolating plant items which are used for the storage of hazardous substances.

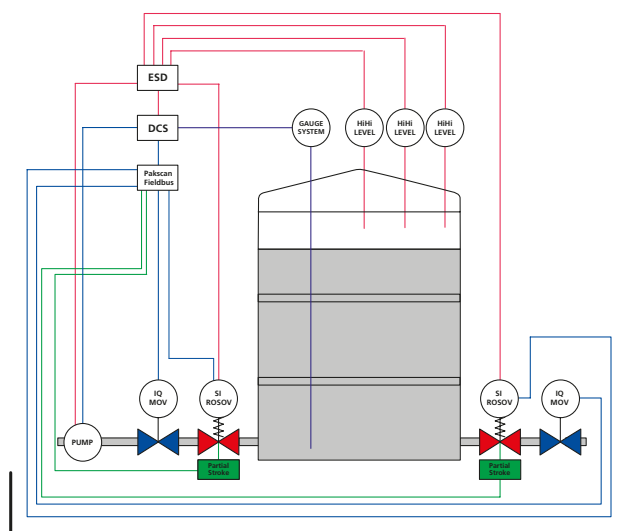
These valves could also be called Emergency Isolation Valves (EIV) or Emergency Shutdown Valves (ESDV). The valves play a major role within the safety system. The standards mentioned below recommend that ROSoV installations are periodically tested to ensure availability of the complete valve, actuator assembly. If a failure is reported as a result of the test, this detected failure can be immediately addressed and a potential undetected failure has now been avoided.

Due to various events in recent years operators and developers have invested heavily in improving their Safety Instrumented Systems (SIS). The SIS can sometimes be separate to the normal control system and usually performs specific control functions. Should an incident occur the SIS will play a significant role in stabilizing the plant, reducing the threat to human life and the environment.

Historically, individual companies would design their own protective systems based on certain industrial standards and company codes of practice. The industry is now moving forward and standards such as IEC 61511, applicable to operators or owners and IEC 61508, applicable to manufacturers are now widely used.

Rotork offer a range of electrically operated spring-return actuators (TÜV verified to SIL 2-3) specifically designed for applications where these standards are being implemented.

The below diagram illustrates where ROSoV actuators (Rotork SI) are being used within the SIS and Rotork IQ actuators are operated via the DCS. This would typically be a SIL 2-3 system.



 **TÜVRheinland®**
Precisely Right.

Rotork SIL Solutions

SIL is an established system of measurement standards to indicate the performance required of a safety system. It is part of a functional safety plan that includes techniques, technologies, standards and procedures that help operators protect against hazards.

Functional safety adopts a life-cycle approach to industries that deal with hazardous processes and includes plans from concept through to decommissioning.

The requirement to meet a given SIL standard is becoming increasingly common in many industrial process environments. It can be a complicated and arduous undertaking to establish and maintain compliance. This is true in both new plant construction and upgrades to the safety systems in an existing plant. Once established, ongoing testing and verification of safety system performance are required for the operational lifetime of the plant.

A plant will have a Safety Instrumented System (SIS) that is made up of a number of Safety Instrumented Functions (SIF). An SIF consists of three sections: Sensors, Logic Solver and Final Elements. SIL applies to the SIF as a whole because a failure of any component compromises the safety function. However, when analysing the performance of the system, it is acceptable to assess the performance of each section separately. The majority of Logic Solvers and Sensors have built-in, automatic testing systems. Final Elements often require additional testing equipment and regimes to test and prove their level of performance.

Assessing the performance of the final elements is a complicated process for the end user. Data for the various components must be gathered, a suitable design must be formulated and then testing regimes applied to the design. This can be a lengthy process involving multiple vendors and a variety of lengthy calculations.

Vendors try and assist in this process by having products independently certified as "Suitable for Use" at particular SIL levels by independent organisations such as TÜV. However, the end user must still conduct all the necessary calculations to ensure that the selected Final Elements as a whole adhere to the requirements for the particular SIL level required.

Rotork's experienced team can provide a variety of products and engineering services that help establish, maintain and verify the Final Elements of an SIS system, often facilitating a reduction of plant operating expense.



Certified Products

- Pneumatic actuators
- Hydraulic actuators
- Electro-hydraulic actuators
- Electric actuators
- Smart Valve Monitor partial stroke test system
- Solenoid control systems

Certified Personnel

- TÜV certified Functional Safety Professionals
- International network of IEC 61508 specialists

SIL System Design Services

- Final element design services for green field sites
- Retrofit solutions for plant upgrades
- Final element SIL verification calculations

Site Services

Rotork understand the value of prompt, punctual and superior site services. Rotork Site Services have specialist expertise, insight and experience in service support for mission-critical flow control and instrumentation solutions for oil and gas, water and wastewater, power, chemical process and industrial applications. We offer global frontline support backed by dedicated in-house experts.

Our service solutions 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.

Rotork Site Services is comprised of two main areas; Lifetime Management and Site Services. Lifetime Management is the suite of services within Rotork Site Services which help you manage the risk associated with aging assets and includes our Reliability Services offering. Site Services comprises essential actuator service, repair, maintenance and upgrades.

Rotork has specialist expertise, insight and experience in flow control.

We provide insight into how we can deliver value to our customers.

Our service solutions increase plant efficiency and reduce maintenance costs.



Site Services

Lifetime Management

The services available within Lifetime Management offer a complete solution to managing the risks associated with the life cycle of your equipment and their obsolescence (which compromise reliable performance and valuable uptime).

The aim of Lifetime Management is to provide you with constant support and minimum- to- no disruption to your production flow. It is a customisable service offering designed to seamlessly maintain and improve your assets. We manage the inherent risks associated with advances in technology, component obsolescence and ageing equipment for you. We are committed to helping customers maximise the continuous, fault-free operation and working life of their actuators. Supporting the continuous and reliable operation of your plant allows for improved performance and increases in valuable uptime.

Lifetime Management covers:

- Reliability Services
 - Health Check
 - Planned Maintenance
 - Enhanced Warranty
 - Predictive Maintenance
- Upgrade Services (retrofit)
- Planned Shutdown Support (service or run time)
- Life Cycle Services (based on years in service or run time)
- Overhauls/Refurbishment
- Customised Spares Programme
- Training
- Consultancy



Site Services

Rotork's Site Services comprises the essential on-site actuator service, repair, maintenance and upgrades part of our service offering, plus the commissioning of new actuators and applications. It includes off-site work completed at a Rotork Support Centre including recertification, automation, testing and product selection.

Our decades of experience in the industrial actuation and flow control markets means that customers can rely on us to understand their problems and to deliver reliable, economic solutions. Rotork's talented and experienced engineers have an in-depth understanding of the problems that are faced in the field and they know how to fix them.

On sites where providing evidence of valid asset certification is a legal requirement, Rotork engineers can carry out the necessary OEM level inspections and provide the statutory paperwork to comply with regulations.

- Planned Shutdown Support
- Actuator Workshop Overhaul
- Field Support
- Valve Automation Services
 - On-site
 - Off-site
- Global Support



rotork®



www.rotork.com

A full listing of our worldwide sales and service network is available on our website.

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