WHITE PAPER

How custom engineered solutions can provide reduced or zero emissions for gas pipeline actuation.

EXECUTIVE SUMMARY

Since the early days of gas transmission pipelines, critical safety-related valves have used the pipeline gas to operate a fluid power valve actuator. Most of these automated valves are located remotely, so there is a lack of alternate power sources. Fluid powered actuators use either a compressible gaseous substance (including instrument air) or a non-compressible fluid to pressurize a chamber in the actuator to create a linear thrust or rotary torque output.

Today, the news regularly focuses on the effects of global warming on our environment, including the **methane emissions** from traditionally controlled gas pipeline valves. Availability of an alternative clean energy source is therefore highly desirable, so the existing pipeline networks can be properly retrofitted.

HOW GAS PIPELINE FLUID POWER ACTUATORS WORK

Gas pipeline pressure is used to power either a linear cylinder (thrust) or rotary actuator (torque) to open and close the valve. If the pipeline gas is untreated (sour), then a **gas-over-oil** type actuator provides a gas/oil interface, keeping the corrosive gas out of the actuator and controls. With treated (sweet) gas, it can directly power the actuator, provided adequate filtration is used to prevent particulates or other contamination from damaging the actuator pressure module seals.

A **double-acting** fluid power actuator uses supply pressure to drive the valve open or closed. A **spring-return** actuator uses fluid power pressure in one direction, but once the pressure is released, a mechanical spring drives the actuator in the reverse direction (known as the failsafe stroke).

Applications for automated valves used in the safe operations of gas pipelines include:

- **Local On/Off Manual Operation** — Lever operated directional control valves.
- **Remote On/Off Operation** — Solenoid operated directional control valves.
- **Safety Related Service** — “Line break” and other shutdown capabilities. The actuator can shut down based on a low-pressure signal from a pipeline pressure transmitter or a remote emergency shutdown (ESD) signal.

Line Break Operation

Line break is a common term in the gas pipeline industry, referring to a specific function required to shut down a gas pipeline in the event of a pipeline breach that could lead to a catastrophic failure. Line break actuators are equipped with pressure sensors to detect a significant rate of pressure drop. The rate of pressure drop is set to avoid nuisance tripping from normal pressure fluctuations, but in the case of a pipeline breach, it closes the valves upstream and downstream of the pipeline failure.

Partial Stroke Testing

Another common function of critical gas pipeline automation is to perform a regular **partial stroke test** (PST) to ensure the valve is ready for service, and has not become stuck in the open position. The PST control function is used to partially move the valve, ensuring it is free to operate without totally affecting the pipeline flow. Once movement has been detected, the PST control returns the actuator to the fully open position. It is important to guarantee the readiness of any valve that is required to perform a safety related service, with the tests even being federally mandated on a regular schedule.

Traditional PST’s require an operator onsite at the valve.

Traditional PST’s are conducted using a manual device on the actuator to prevent the valve from fully closing. It requires an operator onsite at the valve when a control signal is sent to the actuator. Once visible confirmation of valve movement has been established, the actuator returns to the fully open position, and the operator removes the mechanical device restricting the valve’s movement.

ADDRESSING EXHAUST GAS EMISSIONS FROM TRADITIONAL GAS PIPELINE VALVE ACTUATORS

Hydraulic fluid is the most efficient operating medium for high torques or thrusts.

Due to the high torques or thrusts needed to operate large diameter and high pressure rated valves, the most efficient operating medium is **hydraulic fluid**. In some cases, hydraulic actuators use a pump to generate up to 3,000 psi (207 bar) of fluid pressure to actuate the valve.

Hydraulic fluid is non-compressible, delivering instantaneous force — whereas instrument air, or a gas, is compressible, requiring pressure buildup before there is enough force to move the valve. Hydraulic pressure also delivers precise positional accuracy and repeatability for a valve that is controlling flow between a fully open or closed position. Most importantly, a pump driven hydraulic actuator **does not vent any power medium to the atmosphere**. Instead, when fluid pressure is released, the hydraulic oil returns to the hydraulic reservoir for reuse on the next actuator power stroke.

Bray offers alternatives to traditional gas-over-oil actuation, using custom-designed hydraulic solutions to meet your unique environmental situation, power options, and budget.

Figure 1 (Right):
Example of SIL 3 capable gas-hydraulic partial stroke testing (PST) actuator recently installed in line break service.

Figure 2 (Far right):
Example of solar power pack to drive electric pump for hydraulic actuator.

REDUCING EMISSIONS USING A GAS-HYDRAULIC ACTUATOR

REDUCED EMISSIONS SOLUTION

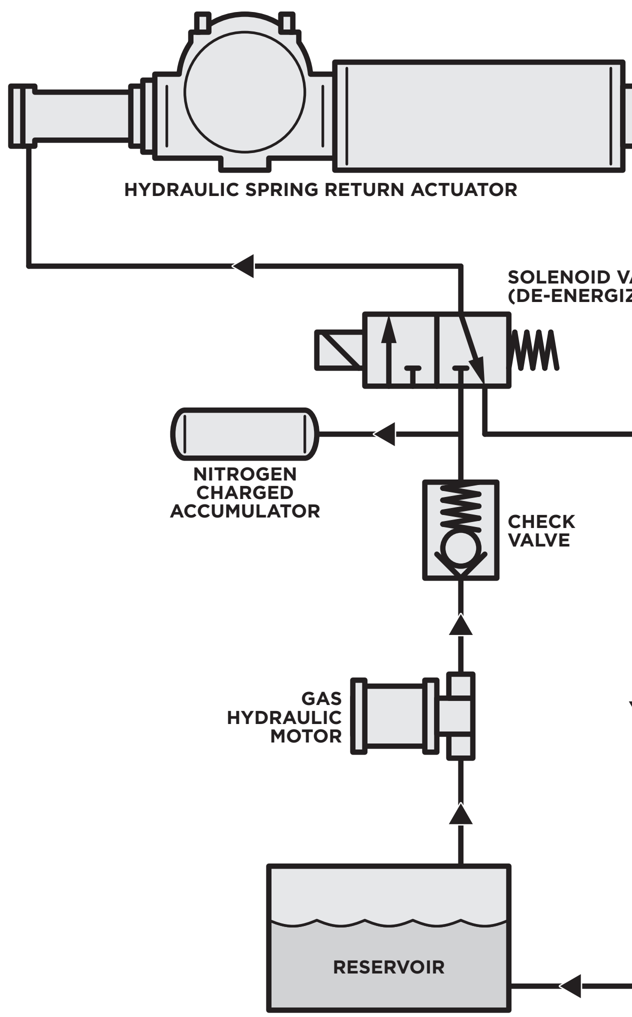
Gas-Hydraulic Actuator

A gas-hydraulic actuator uses hydraulic pressure to operate the valve. This pressure comes from a gas-powered hydraulic pump that charges a hydraulic accumulator to store multiple valve strokes. This **significantly reduces** the amount of pipeline gas per valve stroke exhausted to the atmosphere.

Most importantly, the self-contained pressurized hydraulic fluid drains back to a hydraulic reservoir for reuse — negating any chance of it combining with power gas and exhausting to atmosphere. With traditional gas-over-oil actuators, hydraulic fluid can breach the pressure module piston seals, causing an imbalance of hydraulic fluid across the gas/oil interface tanks. Once either tank becomes full, it will allow some of the hydraulic fluid to exhaust to atmosphere with the power gas. You can usually find evidence of this in the field with a film of oil contaminating the ground below the valve.

Figure 3:
Sample diagram for a gas driven hydraulic actuator.

OPTIONS
- > **Local on/off control**
- > **Remote on/off control**
- > **Emergency shutdown**
- > **Automatic line break control**
- > **Electronic PST capability**



ZERO EMISSIONS USING AN ELECTRO-HYDRAULIC ACTUATOR

Energy needed to operate a hydraulic pump can come from a variety of sources — including mains electric supply, portable generators, a solar-charged battery bank, or wind energy — without having to resort to using the pipeline gas pressure.

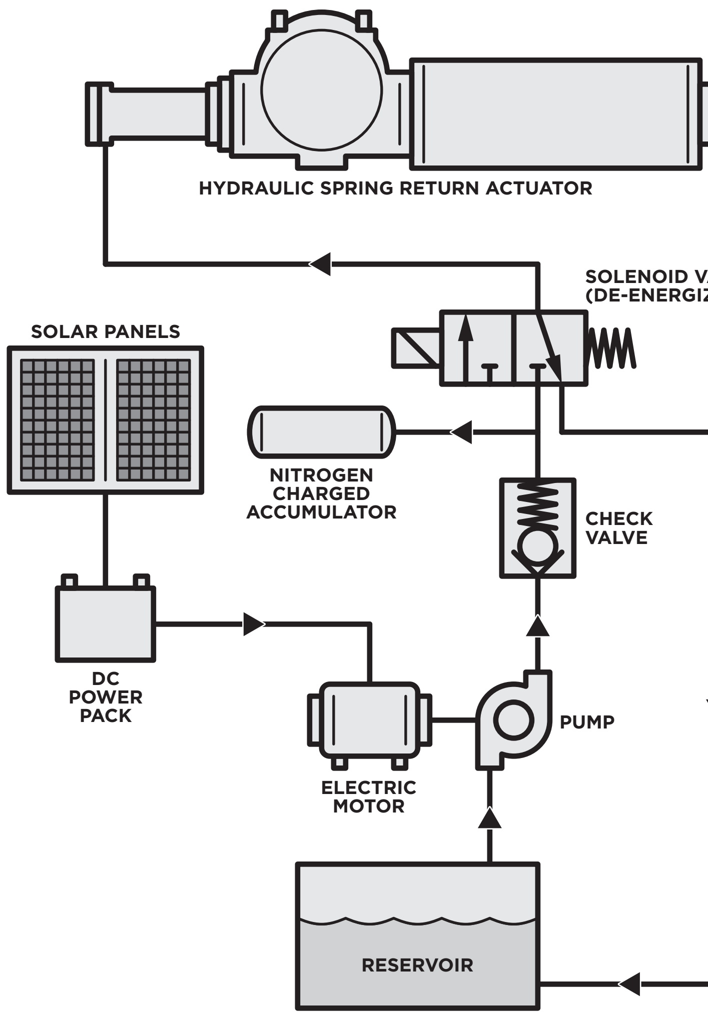
When selecting and sizing an actuator, there are more considerations than just the valve torque demand and safety factor, including the valve stroke speed and failsafe capabilities (fail open, fail close, or fail in position). These are key to selecting the most efficient hydraulic actuator and pump combination.

Bray's electro-hydraulic actuators are engineered solutions for each application.

In remote installations with limited available energy sources, energy conservation is critical. Bray's electro-hydraulic actuators are engineered solutions for each application, utilizing available power options and selecting efficient energy storage to perform multiple valve strokes — without having to constantly run the hydraulic pump.

Figure 4:
Sample diagram for a solar-charged battery powered hydraulic actuator.

OPTIONS
- **Local on/off control**
- **Remote on/off control**
- **Emergency shutdown**
- **Automatic line break control**
- **Electronic PST capability**



Electronic partial stroke testing can be performed without the need to have an operator in the field to control the valve movement.

Principle of Operation

Hydraulic pressure to run the actuator is readily available from a pump, a hydraulic accumulator, or a combination of both. If a stored energy accumulator is being used to maintain hydraulic pressure, the system will be monitored using a pressure switch, and the actuator controller will run the hydraulic pump to “top off” the system. Therefore, pressure is always available when either a double-acting or spring-return actuator is required to stroke the valve one or more times.

The principal of operation is the same as the gas-powered hydraulic pump, except the pump is driven by electric solar-charged batteries, a portable generator, or wind turbines. The nitrogen-charged accumulator’s pressure sensor will trigger the hydraulic pump to recharge the accumulator when a low pressure is detected.

Electronic PST’s can be performed without the need to have an operator in the field to control the valve movement. The actuator control system can accept a remote PST signal and begin the actuator closing. A dedicated limit switch is set to trip at 10% closed, to cancel the PST signal, allowing the actuator to return to the fully open position. The electronic PST also incorporates a timer function, so that partial movement is registered within the standard stroke time.

Line break is also achievable using pipeline pressure transmitters to signal the actuator’s controller when the line break sequence is required. The pressure sensors will trip the line break valve controls usual manual “reset” function on the actuator as part of the reopening valve sequence. The actuator will not reopen unless a remote signal to open is present and the local “reset” button is pressed. The valve can also be closed during normal operations through a separate dry contact to initiate a close.

ENGINEERED TO MEET CUSTOMER SPECIFIC NEEDS

Using custom design, Bray can provide a cost-effective actuator with a low cost of ownership.

In today's market, there are electro-hydraulic actuator brands that offer a high level of standardized features and benefits, which come with a high price tag. However, many applications do not justify that level of specialization or investment.

Custom designed electro-hydraulics follow the simple principal of using tried and trusted components to design and build hydraulic actuators that meet the customer's exact technical specifications. With standard off-the-shelf items that can be easily sourced locally, Bray can provide a cost-effective actuator with a low cost of ownership that can be serviced and maintained in the field by the end user.

When choosing the right product for your application, factors to consider include complexity in design, cost, quality, reliability, and serviceability. The journey starts with Bray's engineering team gathering customer-specific requirements to identify what's essential for the application. Budgetary sizing and pricing can be offered at the feasibility stage, as well as electronic drawings and schematics that can be included in design modeling process.

Bray will custom design the electro-hydraulic actuator to meet your functional requirements. Our hydraulic power unit can either be self-contained or a free-standing skid mounted hydraulic power unit that can supply hydraulic pressure for multiple actuators.

SAFETY INTEGRITY LEVEL

Recently, the industry has adopted Safety Integrity Levels (SIL) on the critical control systems in these types of facilities. A SIL rating is a calculation on the **possibility** of a system failure based on the safety rating of each system component, plus the control system architecture. These factors all contribute towards a level of reliability and redundancy that will determine the SIL rating. Built-in capabilities, such as an electronic partial stroke testing (PST) capability, will increase the SIL rating of an automated valve package. Bray can provide safety related valve and actuator packages with a **single SIL rating** for easy integration into the overall process.

AVAILABLE MECHANICAL FEATURES FOR BRAY S98 SCOTCH YOKE ACTUATOR

Hydraulic Manual Override

If there is no electrical power, the actuator can be manually opened using the integral hydraulic manual override pump. This can be part of an integral hydraulic power unit or a standalone hydraulic manual override if the hydraulic power unit is remotely located

Actuator Stroke Speed Control

Actuator opening and closing speeds are controlled by adjustable flow control valves in the hydraulic circuit.

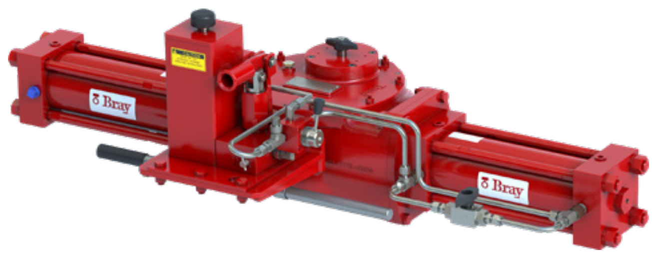


Figure 5:
Example of Series 98 Scotch yoke actuator with an independent hydraulic manual override.

Position Indication Limit Switches

An additional pair of limit switches (1 x Open, 1 x Closed) are normally provided for the customer's independent use. These limit switches are independent from the actuator control system, and provide verification of actuator position to the customer. These limit switches could provide indication of a solenoid failure during valve stroke.

Figure 6:
Example of limit switches for use independent of the actuator control system.

Mechanical Partial Stroke Testing Device

If the customer wants a more traditional partial stroke testing (PST) device, the Bray S98 actuator has an optional mechanical PST device that is integral to the scotch yoke mechanism, and not an independent device built into the valve actuator coupling.

The mechanical PST device requires a manual intervention on site to engage the device. A dry contact signals the control room whenever the device is engaged, to avoid accidental engagement when a PST is not taking place. The actuator can then be remotely operated, as the mechanical PST will restrict the actuator's movement. The partial movement can be visually confirmed by the site operator, or remotely through a conventional limit switch set to activate at the end of the partial stroke. The control room can then reopen the valve, and the mechanical PST can be disengaged and padlocked.

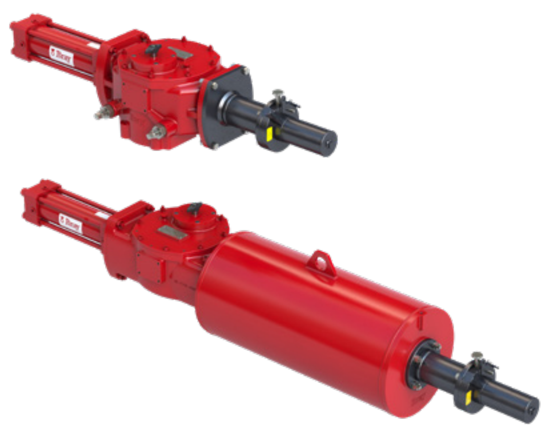


Figure 7:
Example of mechanical partial stroke testing device.

Valve Seating Dampener

For some applications, the spring failure stroke is required to operate in less than one second. This is achievable with our S98EH actuator using flow components with the highest Cv (Kv). However, it is sometimes required that we avoid potential physical damage from slamming the valve into the valve seat. For this, the Bray Series 98 offers a hydraulic dampener module that can be fitted to either a double acting or spring failsafe actuator. This hydraulic shock absorber can be calibrated to absorb the linear force of the pressure module by as much as 20% of the travel. This will ensure that the stroke time remains fast, but the end of the stroke gently enters the valve seat.

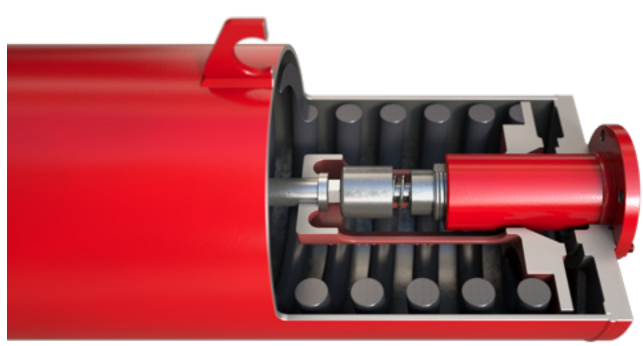


Figure 8:
Example of hydraulic dampener module.

CONCLUSION

The **electro-hydraulic** actuator is best suited for reliable safety related functions. Traditional gas-over-oil and direct-gas actuators often rely on conventional pneumatic controls, and will exhaust pipeline gas to the atmosphere. Self-contained electro-hydraulic actuators use minimal or no pipeline gas to actuate the valve, depending on the method selected for pressurizing the hydraulic fluid.

Additionally, Bray's electro-hydraulic actuators use standard fluid power components to match the customer's exact specifications. Spare parts can be locally sourced, to allow the customer to maintain the actuator without a factory service technician — resulting in peace of mind and a lower cost of ownership. Critical failsafe functions, such as line break and PST, are maintained using a state-of-the-art programable logic controller that meets the level of redundancy required for each application.

Safe operation is the highest priority for any midstream installation including transmission lines, metering stations, compressor or pumping stations, and product storage. Bray can assist with identifying the right valve and actuator products to use, from the initial feasibility stage to the final installation and startup.

ABOUT THE AUTHOR

Howard Williams is Business Development Manager for Actuation & Controls at Bray International. With a degree in Marine Mechanical Engineering and an MBA, Howard has over 38 years in valve automation.