

# Partial Stroke Testing

White Paper 5.3 ©

## Explaining Why Users Correctly Don't Trust Pressure Regulating SOV & Smart Positioner PSTDs .... and The Solution

### QTRCO - The Leader in Actuator Technology

- Basics of pressure regulating PSTD s
  - Actuators
  - Flawed theory
  - The solution

PARTIAL STROKE TESTING CONFIRMS ONLY THE ABILITY OF THE VALVE AND ACTUATOR TO OPERATE OVER A LIMITED RANGE OF TRAVEL. PARTIAL STROKE TESTING DOES NOT PROVIDE ANY KNOWLEDGE WHATSOEVER OF THE VALVE'S ABILITY TO ACHIEVE A TIGHT SEAL WHEN FULLY CLOSED.

### Intent of Partial Stroke Testing:

- Decrease the average Probability of Failure on Demand of the ESD Valve
    - Safely extend time periods between maintenance activities
- PST Device should accomplish the intended tasks with:**
- No detrimental impact on the emergency function
    - No process interruption or shutdown
  - Proper operation over a full range of applicable process and ambient variables



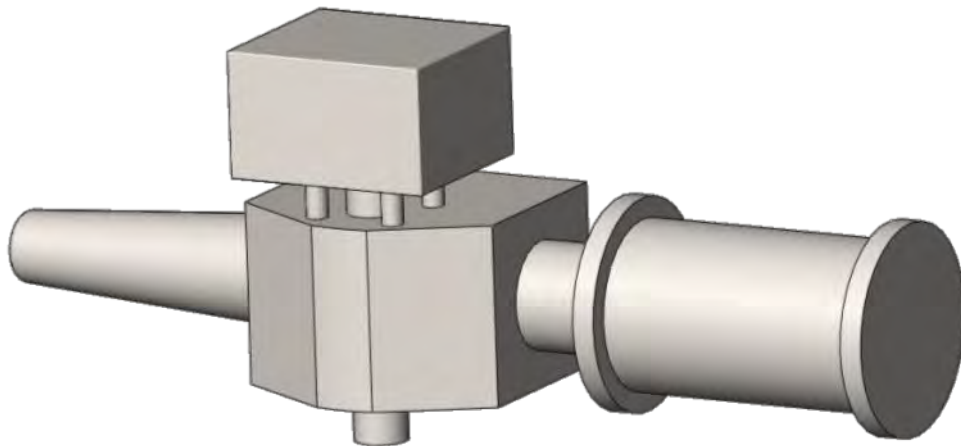
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## Assessing Pressure regulating SOV & Smart Positioner PSTDs

### **The basic concept:**

- The actuator spring is fully compressed and the ESD Valve held open, by pressure acting on the actuator's piston.
- Exhausting the pressure allows the spring to cause closure of the ESD valve.
- Partially exhausting pressure allows the spring to partially close the ESD Valve.
  - If exhausted properly the actuator will cease motion at a desired partial stroke position.
- Solenoid valves (SOVs) and positioners can be employed to exhaust pressure.
  - Pressure exhaust ceases once the PST position is achieved.
  - If performed slowly and if time to stroke is observed, the PST test can be aborted if a sticking valve or actuator cause deviation from the expected time / position relationship.



### **Pros:**

- Local or remote control.
- ESD valve can be closed during partial stroke testing in the event of an emergency.
- Diagnostics are commonly available.

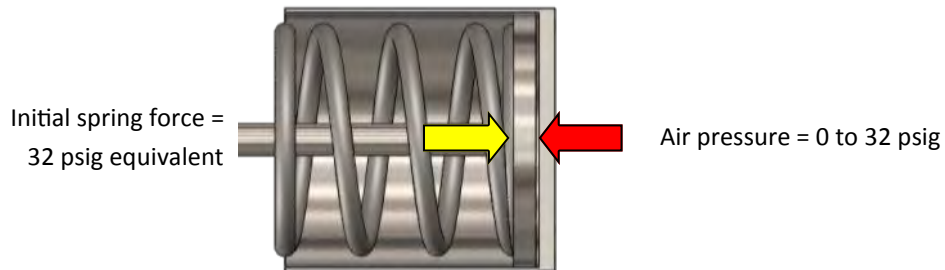
### **Cons:**

- There are no hard travel stops to assure stopping at the partial stroke position.
- A very small percentage of the rated actuator torque is available.
- Diagnostics data is typically time based, confusing and relatively meaningless.
- Spurious travel or aborting the test is likely should the valve or actuator initially resist movement.
  - PST aborted on basis of response time.
    - Numerous causes, other than a bad valve or actuator (including changing process variables) may impact stroking time.
    - Aborted PST requires analysis and costly maintenance.
- Incompatible requirements - slow pressure exhaust for PST / rapid exhaust in emergency.
- Extensive operator training required.
- High cost expert commissioning assistance required.
- No PSTD is of value if operators are afraid to use it

**To explain why the concept of pressure regulation is flawed, let us begin with the actuator:**

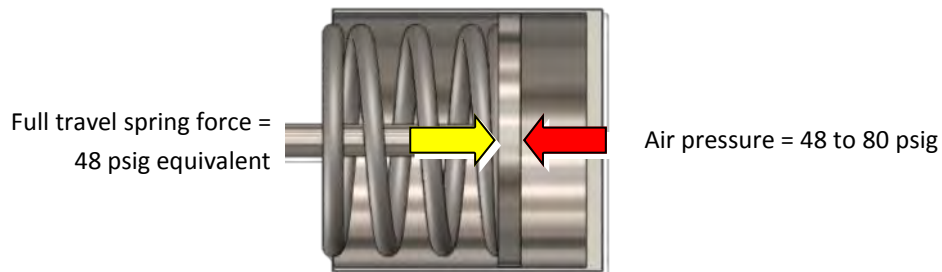
**Full travel of spring return actuators occurs over a small pressure range**

- In one direction of travel, air pressure acts on the surface of a piston to produce force and motion.
- A spring pushes against the piston to cause reverse motion.
- As air pressure causes piston motion it compresses the spring, increasing the spring force.
- Net air pressure force diminishes in direct proportion to the increasing spring force.
  - Initial spring force usually equals approximately 40% of the available air pressure.
  - At full stroke, spring force commonly equals 60% of the available air pressure.
  - Full actuator travel therefore occurs over the range between 40 and 60% of the air pressure (varies by supplier but always a relatively small percentage of the supply pressure).
  - For example, if we assume an 80 psig supply pressure, initial actuator motion (no valve attached) occurs at 32 psig (40% of 80) and full travel at 48 psig (60% of 80). Therefore **the pressure change from zero stroke to full stroke is only 16 psig.**



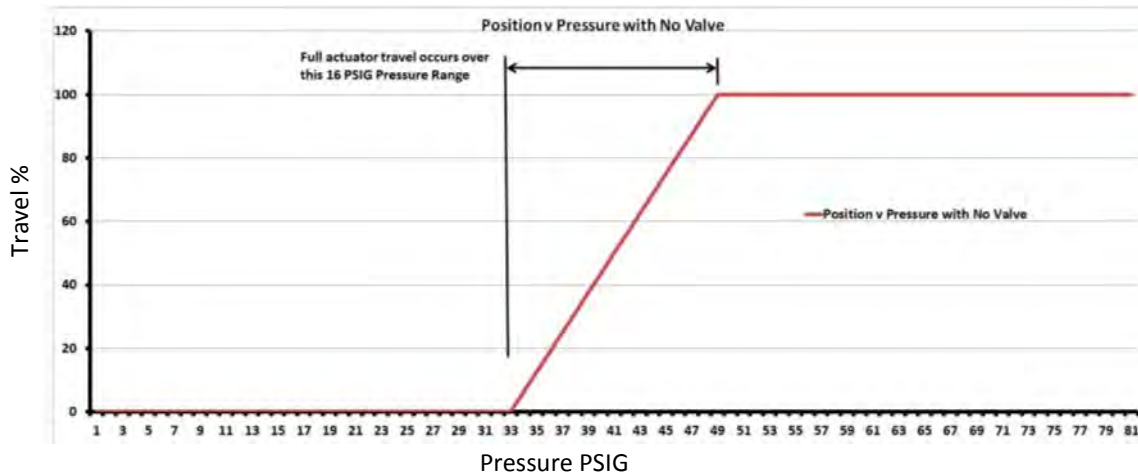
**Zero travel position (No valve attached)**

Motion does not occur until pressure force exceeds the initial spring force



**Full travel position (No valve attached)**

No further travel occurs regardless of increasing pressure

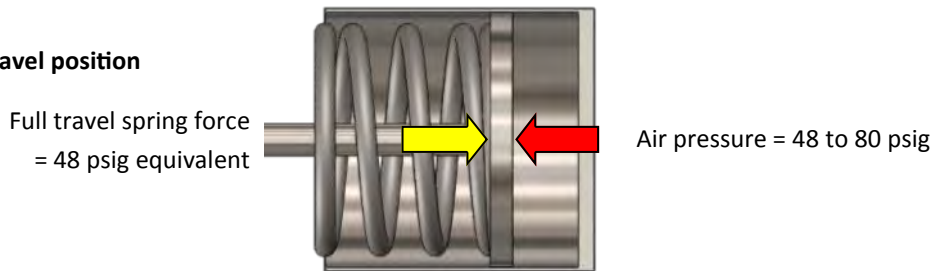


**How pressure range pertains to pressure regulation via SOVs & smart positioners (no valve attached)**

To perform a Partial Stroke Test:

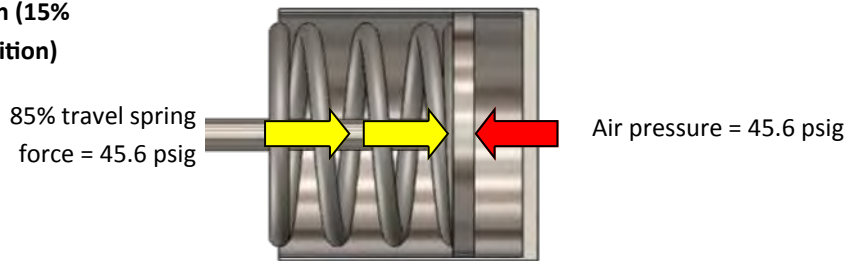
- Begin with the spring fully compressed (fully open ESD Valve).
- Assume PST position is 15% toward the closed position (85% open).
- Pressure range for full travel = 16 psig
- 15% of the 16 psig pressure range = 2.4 psig
- Slowly decrease the air pressure to 48 psig, and then an additional 2.4 psig (45.6 psig) for 15% travel
- Confirm PST position has been achieved within allowable time (if not abort the test)
- Re-pressurize the actuator to cause full open travel
- Transmit diagnostics data (typically time based) for analysis

**Full (100%) travel position**



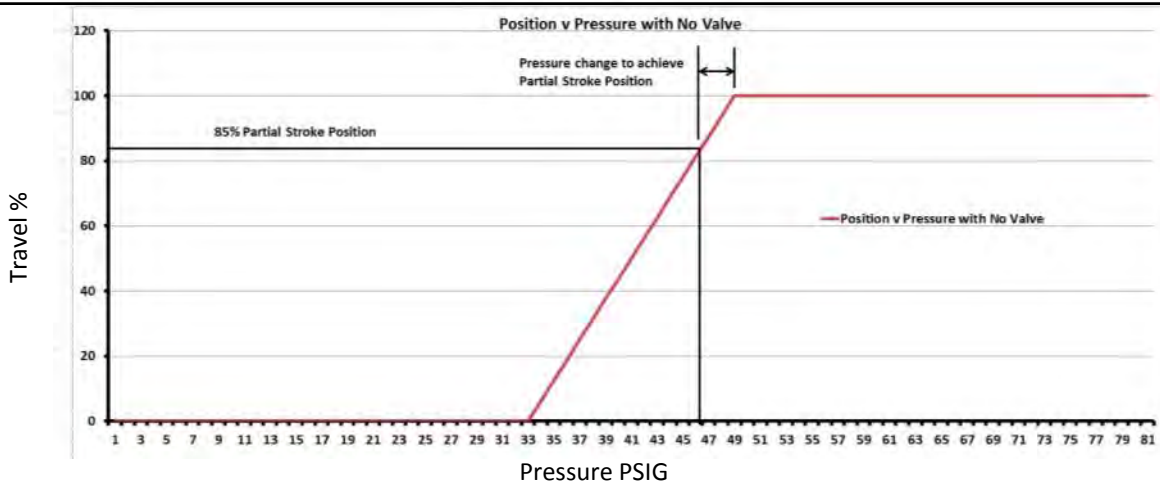
When fully stroked, spring force is equivalent to 48 psig air pressure. No valve attached.

**85% travel position (15% toward closed position)**



When at 85% travel position, spring force is equivalent to 45.6 psig air pressure. No valve attached.

**The RED line below represents the pressure to both open and close a valve when there is no valve resistance. Note that PST travel begins when pressure falls below 48 psig and the PST position is reached when the pressure has decreased to 45.6 psig**

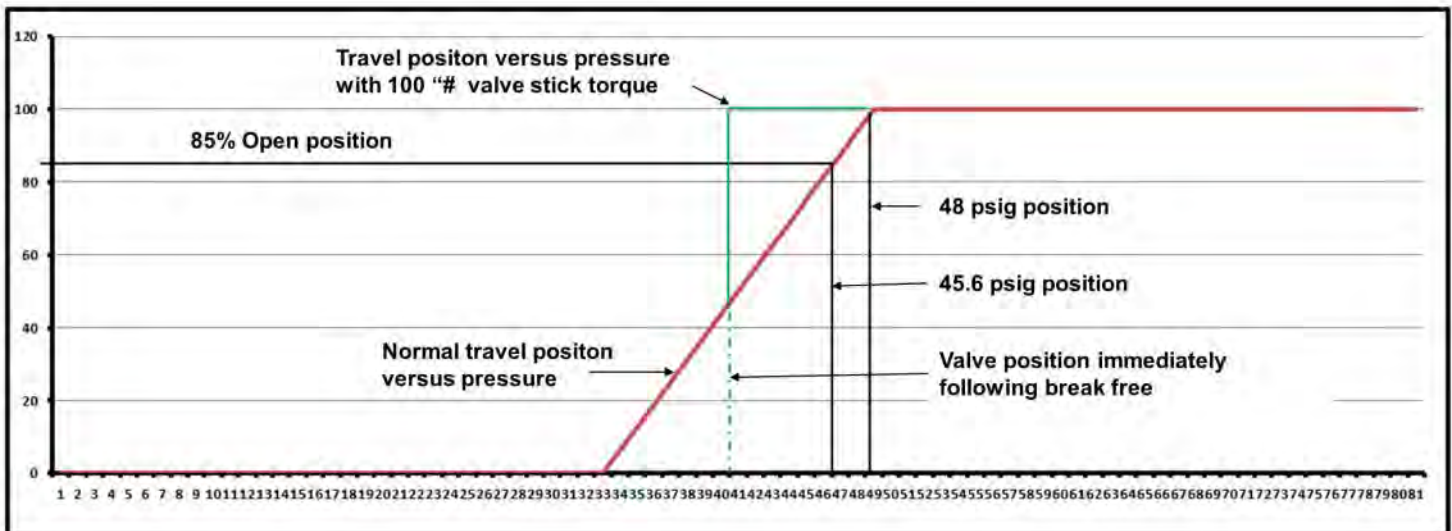


### **Available torque when pressure is reduced from 48 to 45.6 psig**

- For the typical spring design, a 1,000 #” rated double acting actuator, provides an initial spring torque of 40% or 400 ”# and fully compressed spring torque of 60% or 600 “#.
- At full travel, when pressure to the actuator is zero, spring torque available is 600 “#
- At full travel, when pressure is from 80 to 48 psig, the available spring torque is 0 “#
- From 48 to 45.6 psig with the actuator in the full travel positon, the available spring torque is  $[(2.4 / 48) \times 600] = 30$  “#
- I.e. in order to move the actuator to the 85% travel position by decreasing the pressure to 45.6 psig, we develop only 30 “# of torque to overcome valve resistance.

### **Adding a valve to the assembly - what if the valve stick and resists initial movement?**

- Assume 100 “# resistance to initial motion (Equals 8 psig equivalent)
- Initial valve motion begins at 40 psig (48, minus 8)
- 40 psig is less than the normally 45.6 psig at 85% PST position
- Actuator will over shoot the 85% PST position - Spurious over-travel has occurred



- Pressure regulating SOV / Positioner PSTDs ‘solve’ this issue by aborting the PS Test if a pre-defined travel response time is not met or if the pressure decreases to near the normal PST pressure.
- An aborted PS Test indicates the need for maintenance even though the time / pressure deviation may not have been caused by valve or actuator deficiencies. Examples:
  - Change in process pressure, flow, temperature
  - Higher than normal pressure to the actuator (takes longer to exhaust)
  - Ambient temperatures

### **The optimum solution**

Develop an actuator that will allow full pressure exhaust while positively maintaining the partial stroke travel position. I.e. introduce pneumatically engaged hard travel stops.

- Allow users to choose the level of PSTD system refinement with full confidence that the actuator will not over-travel.
- Having full confidence that process disruption will not occur, the user may then increase the frequency of partial stroke testing to further lessen the negative effects of contaminants and corrosion, and to extend maintenance intervals.

## The QTRCO XRCISER™ Hard Stop Pneumatic Solution

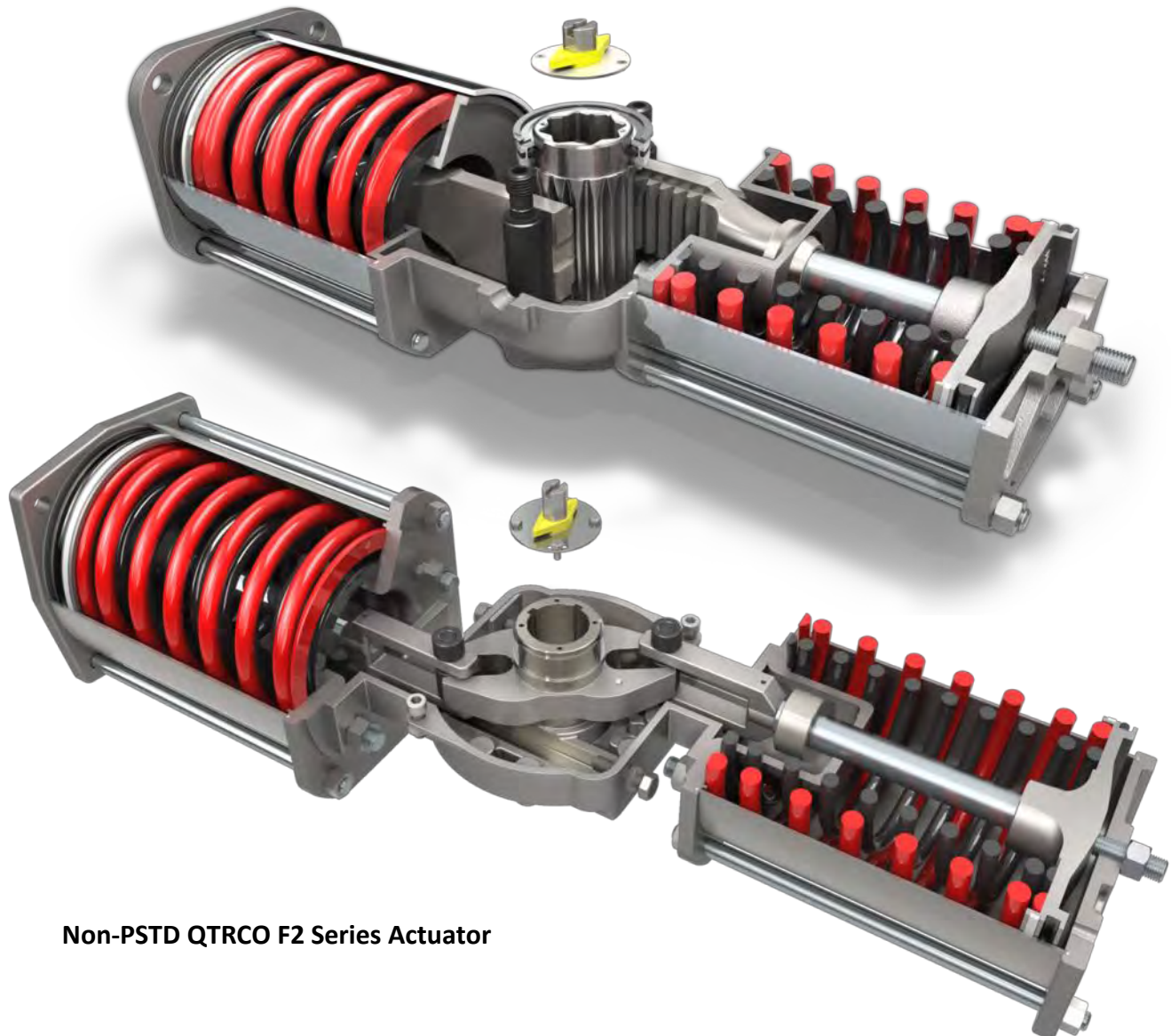
**Begin with the exceptional Rack & Gear™ or Flat Yoke™ actuator.**

- Both are designed for exceptionally long service life in light, medium and extreme duty applications, whether running at controlled slow speeds or full travel in less than 1/10th second.
- Available in ductile iron or all stainless steel constructions in sizes from 100 to 500,000 pound inches torque output.
- Pistons travel outward under spring force until contacting travel stops located in the end caps.

Replacing the travel stop screws with pneumatically engaged outward travel stops enables the actuators to readily achieve positive partial stroke positioning capabilities.

*See separate product brochure or the QTRCO web site for the many features and benefits of the base actuators.*

**Non-PSTD QTRCO Q2 Series Actuator**

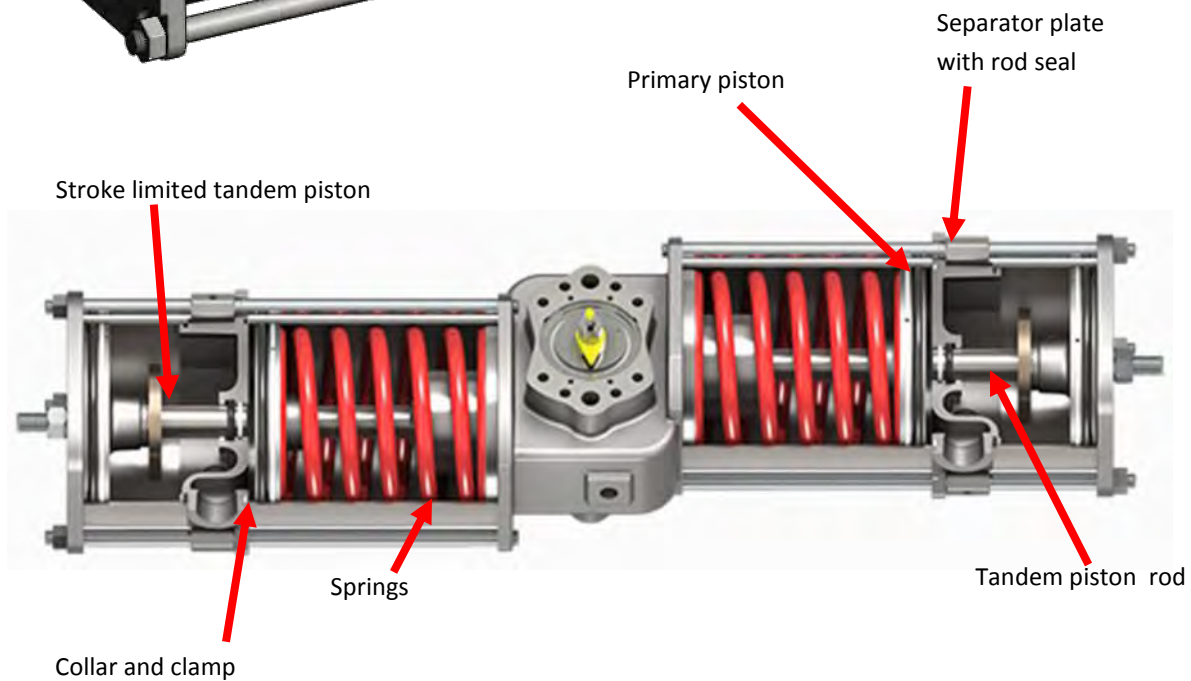
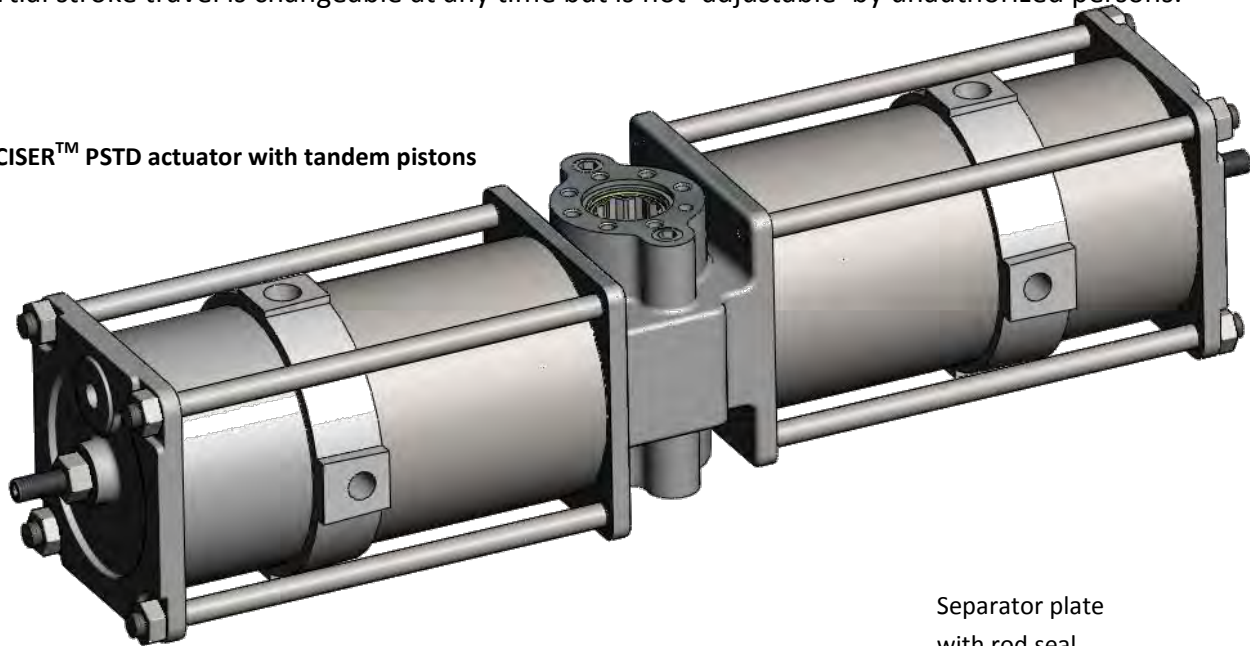


**Non-PSTD QTRCO F2 Series Actuator**

## Adding PSTD capabilities to the basic QTRCO actuator via pneumatically engaged hard travel stops

- Added tandem pistons serve as pneumatically engaged hard travel stops for the primary pistons.
- Spurious valve travel is eliminated.
- Partial stroke travel is changeable at any time but is not 'adjustable' by unauthorized persons.

The XRCISER™ PSTD actuator with tandem pistons



### **Benefits:**

- All of the inherent longevity and performance capabilities of the basic Rack & Gear™ or Flat Yoke™ actuators
- Positive, hard stop assurance against spurious over-closure
- Functions equally as well on all size actuators and on high or low speed applications
- Local or remote control
- Easily interpreted predictive diagnostics data
- Failure free even with frequent testing
- Applies 100% actuator torque
- Inherent redundancies (remains operational with any 2 of the 4 piston seals having failed)
- Retains emergency shut down capability while partial stroke testing is in process
- No special training of operating personnel

**Intelligent diagnostics - predictive, meaningful and understandable**

- Provide pressure versus initial valve motion
- Compare to signature, historical and multiple test values
- Clearly see trends and real time performance issues

Example alarms

- Available actuator torque far exceeds normal valve resistance
- Should safety margin fall below user preferred values, both tabular and graphical indicators will show, first to 'Advise' then to 'Warn' as per user preference
- System option is to not permit actuator pressure to exhaust below the MAST value

**Screen shot of typical tabular and graphical diagnostic output**

Test Interval	Closing Pressure (PSI)	Closing Spring Torque (lbin)	Actuator Rated Torque Output (lbin)	Closing Safety Margin (%)
Signature Test	46.64 PSI	76.86 lbin	2740 lbin	97.19 %

Demo Number	Closing Pressure (PSI)	Closing Spring Torque (lb-in)	Actuator Rated Torque Output (lbin)	Closing Safety Margin (%)
Demo 5	34.86	749.49	2740	72.65
Demo 5	44.39	205.33	2740	92.51
Demo 5	46.93	60.30	2740	97.80

**QS10SR-S30 Rated Torque Output = 2740 lbin**  
**Spring Torque Output (lbin) = 2740 - (57.1 \* (Closing Pressure))**  
**Closing Safety Margin (%) = 1 - ((Spring Torque Output) / 2740) \* 100**

