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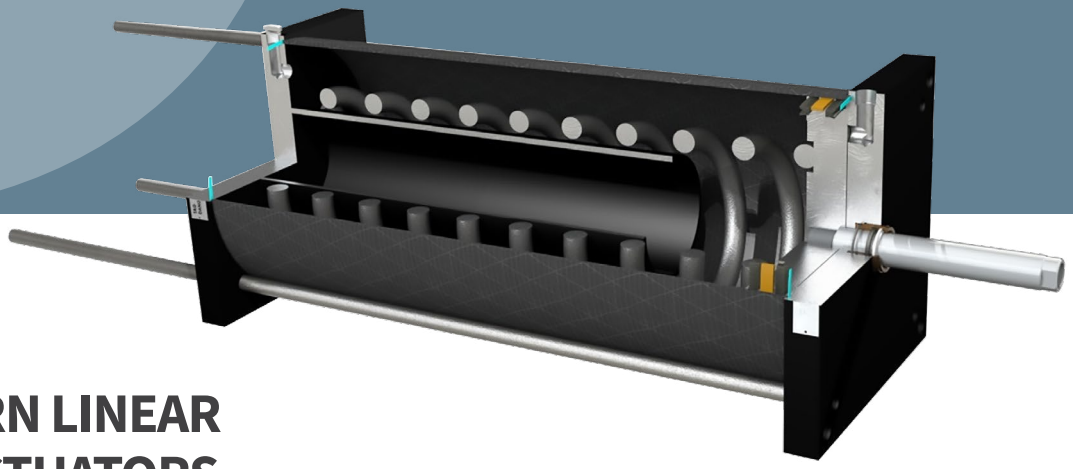

SPRING RETURN LINEAR PNEUMATIC ACTUATORS

Basics 101

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Introduction

Spring Return Actuators, also referred to as single acting actuators or mechanical fail safe actuators are a positive way to mechanically open or close a process valve upon loss of air pressure and/or electricity. These types of actuators are carefully calculated and designed by actuator manufacturers in conjunction with the valve manufacturer and their distributors in order to retrieve the specific information of the installation, application parameters, and thrust requirements.

When a fail-safe feature is required, spring return cylinders are a simple solution. Mechanical springs can provide the force to move a load to a predetermined point, considered its fail-safe point.

Mechanical spring actuators are available in two different configurations and are primarily described below in the case of knife gate valves when the actuator is mounted on top of the valve:

SPRING TO EXTEND PISTON ROD –
SPRING TO CLOSE VALVE

SPRING TO RETRACT PISTON ROD –
SPRING TO OPEN VALVE

Spring to close valve (spring force to extend piston rod, air force to retract piston rod): Actuator will stroke to fully extend its piston rod therefore fully closing the valve when the air pressure is removed from the rod end port. Air to the rod end port will compress the mechanical spring, therefore retracting the rod into the actuator and opening the valve.

Spring to open valve (spring force to retract piston rod, air force to extend piston rod): Actuator will stroke to fully retract its piston rod therefore fully opening the valve when the air pressure is removed from the cap end (blind end port). Air to the cap (blind end) port will compress the mechanical spring, therefore extending the rod out of the actuator and closing the valve.

Mechanical spring actuators are ideal for applications when the process valve is required, for any reason, to fully close or fully open if input pressure is removed by the control or lost by accident. In most circumstances, a mechanical spring is the only device that can be integrated into an actuator to consistently deliver a specific design force when input pressure is lost and retain that force for as long as the actuator to valve assembly is maintained.

The mechanical spring is preloaded and protected inside of the actuator and provided with extended tie rods on the cap end of the actuator to safely service the actuator, if required. All actuators have multiple riveted warning tags on the actuators to identify this option and an additional larger sticker warning. If other indicative tagging or design is required, please consult factory.

Designing Mechanical Spring Return Pneumatic Actuators

When designing spring return actuators, the more information received by the actuator manufacturer, the better. Pertinent information that must be provided should include:

Spring to Fail Valve Open or Closed:
Do you want your valve to open or close as the fail safe position?

Minimum available air supply pressure to the actuator: This would be the air pressure in psi that the spring return actuator would require to fully compress the internal spring and thus open or close the valve fully. Note the lower the available air pressure, the larger the resulting actuator diameter (bore).

Maximum Working Pressure of the valve (DeltaP) in psi: What would be the maximum working pressure of this valve in the application?
This provides the valve manufacturer and actuator manufacturer the information to determine the thrust requirement.

Media and Temperature through the valve:
This helps the valve manufacturer and actuator manufacturer determine thrust requirement.

Installation:
Is the valve mounted horizontally or vertically in the line? This helps the valve manufacturer and actuator manufacturer determine thrust requirement.

Total Required Thrust in lbs (force required):
Calculated by the valve manufacturer as they know their static load force, valve packing friction factors, weight of gate, and the seating thrust for the type of valve they are proposing. This can be affected by different packing configurations and sealing materials. A safety factor is built into this force requirement for smooth valve operation and to move the load with sufficient speed. Additionally, the actuator manufacturer will build in the required safety for the tolerances of the coiled spring rate, actuator running friction factor, weight of components, and to assure the spring force will keep the valve fully open or closed.

Travel required to open/close the valve (stroke of the cylinder) in inches:
This is determined by the valve manufacturer and required travel for the valve's size and design. Spring return actuators are much longer than double acting. Their length must include the required stroke, the spring, the piston, and mechanical stop. Typically, spring return actuators will be a minimum of 2-3 times the length of a double acting but can exceed this easily. Please consult the factory if there are any space restrictions, height or width, and we will design accordingly.

Construction

The mechanical spring rate is specified in pounds per inch and is determined by how much load the actuator will be required to move, per all the information received on the valve and application.

In most cases, one spring can generate the design forces and meet the requirements of the actual stroke such as in the illustration above. In some circumstances, multiple springs may be required to generate the thrust requirement necessary due to limitation in size and availability of the spring.

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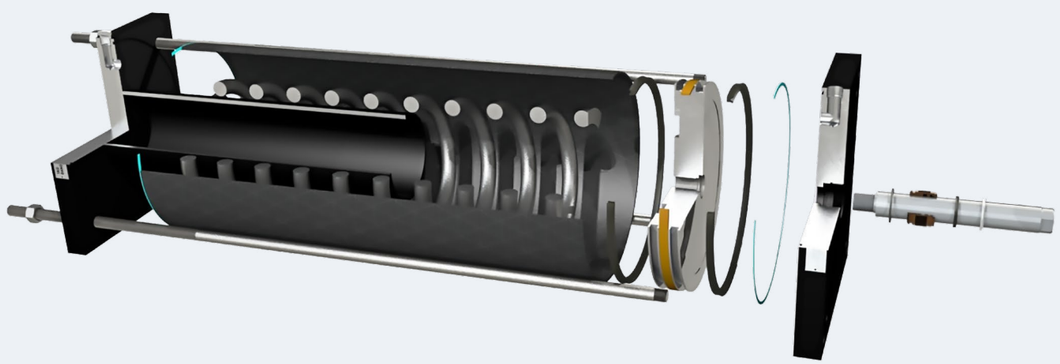
When spring return actuators are designed correctly and operated within its stress limits, service life of the actual spring is limitless. A stop tube or stop collar is incorporated into the actuator design in order to prevent the spring from being over compressed. In addition to this positive stop preventing the piston from over compressing the spring when energized with air, it also helps guide the spring.



Understanding Spring Thrust

A single spring provides the forces as delivered by the rate of the individual spring selected. Example: a 100-lb/in. rate spring will provide a force equal to the 100-lb/in. rate, times the number of inches the spring is compressed. Therefore 4 inches of spring compression will provide a 400-lb total spring force.

The spring rate and its pre-compression into the actuator are determined by our Engineering department. Every inch of pre-compression adds additional force to the actuator in order to obtain the beginning of stroke thrust requirement and end of stroke thrust requirement. When the spring is fully compressed inside the actuator, it is known as spring final load. When the spring is relaxed inside the actuator, it is knows as spring preload.

EXAMPLE

Spring to close valve (spring force to extend piston rod, air force to retract piston rod):
If a 4” valve (with 4” stroke) requires 4500 lbs (including safety) of spring force to fully close and seat the valve and 4500 lbs to “crack open” the valve with air pressure when initially starting its stroke. The spring preload (or pre-compression of the spring) in the actuator would be a minimum of 4500 lbs + actuator manufacturer’s safety. Spring in relaxed position with piston rod fully extended and valve fully seated.

The diameter of the actuator (bore) must be large enough to then compress this spring fully (and keep it compressed) with the minimum air supply pressure until the full valve opening (or cylinder retract stroke) is achieved. This thrust generated by air must overcome not only the increasing spring force while the spring is being compressed, but also have enough thrust to open the valve against the working pressure, friction factors, weight of the gate, and with sufficient speed. If for example, the spring rate was 1000-lb/in, the final load of the spring inside the actuator would be:

4500 (preload) + 4000 (1000- lb/in*4 inches travel) = 8500 lbs.

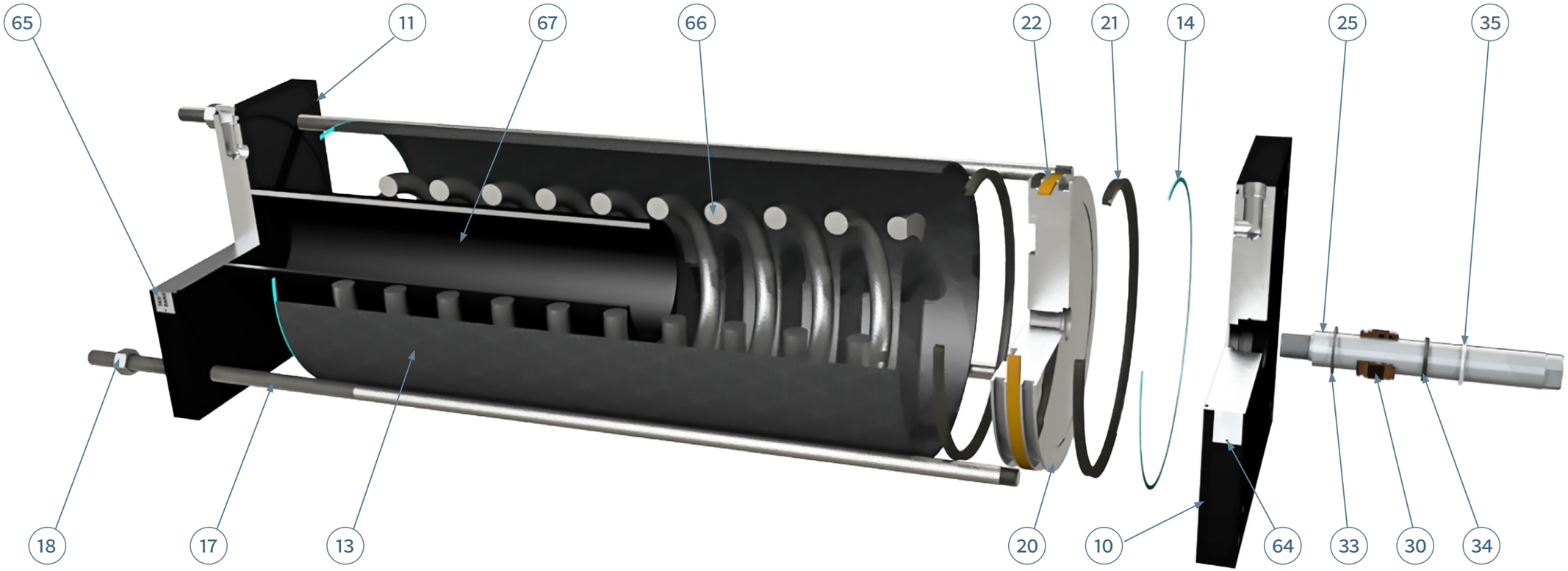
The bore of the actuator with minimum air supply pressure must generate a minimum force of 8500 lbs + enough force to compensate for the valve friction and physical weight of the gate. This resulting force from the properly sized diameter actuator sized with minimum air pressure will fully retract the piston rod and thus open the valve completely. This is why it is very common for spring return actuator bores to be one, two, three or more sizes larger than the equivalent double acting actuator.

Exploded View of Standard Spring Return Actuator Components

PART #	QTY	DESCRIPTION	MATERIAL
10	1	Head	Steel
11	1	Cap	Steel
13	1	Barrel	Composite
14	1	Barrel Seal	Teflon Composite
17	1	Tie Rods	Steel
18	1	Nuts	Steel
20	1	Piston	Steel
21	1	Piston Seal	Nitrile
22	1	Piston Wear Strip	Teflon
25	1	Piston Rod	Polished & Chromed Steel

PART #	QTY	DESCRIPTION	MATERIAL
30	1	Bushing	Bronze
31	1	Piston Rod Seal	Nitrile
33	1	O-Ring	Nitrile
34	1	Bushing Seal	Nitrile
35	1	Wiper	Polyurethane
50	1	Breather	Bronze
64	1	Identification Tag	Stainless Steel
65	1	Tag Danger	Aluminum
66	1	Spring	Steel
67	1	Stop Tube	Steel

Standard materials shown.



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