Electraulic™ Actuators & Drives

Product Memo

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Spring Fail-Safe Option

Among the many advantages of REXA Electraulic™ technology is the ability to provide a simple, reliable and compact spring fail option. Upon loss of electrical power or a trip signal, the actuator can be specified to travel to either end position. Several factors must be considered when selecting a spring fail-safe actuator. In order to do this properly, a basic understanding of springs forces and their effect on the actuator output is provided.

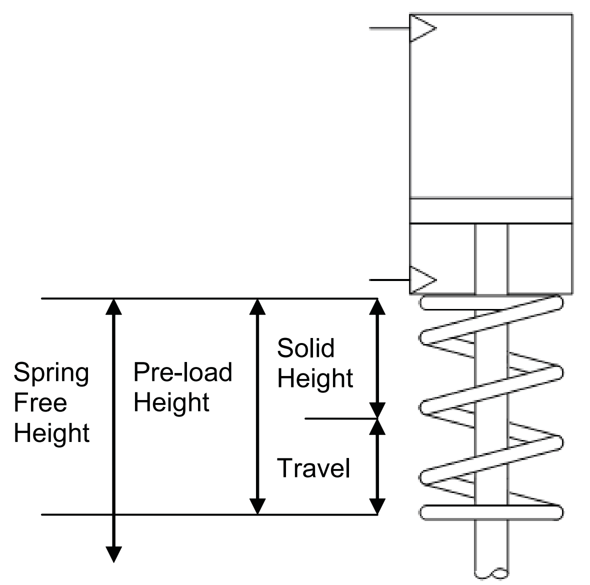
THEORY OF OPERATION

Spring fail-safe units require the addition of a helical spring assembly and solenoid valve to a standard REXA actuator. As long as electrical power is present, the solenoid is energized and the actuator will operate in its normal control mode. Upon removal of solenoid power, the valve opens directly connecting both chambers of the hydraulic cylinder. The spring will now move the actuator stem to the selected failure position. The spring can be specified to drive the cylinder in either direction, but is not field reversible. A spring fail event may be initiated via a trip signal, loss of electrical power, loss of control signal or a combination of these situations.

SPRING DESIGN

The design of each spring defines its physical characteristics such as;

- Free Height – length of the spring when under zero compression load
- Solid Height – length of the spring when the coils come together and the spring can not be compressed any further
- Endurance Limit – the maximum amount you should compress a spring continuously to insure it will not fail due to fatigue
- Spring rate the constant that defines the amount of force a spring generates for a certain compression length



A spring will exert as much force as is required to compress it to that height. The force required to compress a spring is the spring rate times the spring deflection (travel). Deflection is limited physically by a spring's solid height. However, good design practice mandates that the maximum load is set such that the endurance limit is not exceeded.

FORCE OUTPUT

The amount of net force output by a spring fail-safe unit is the cylinder's force plus or minus the spring's force, depending upon direction. The spring and cylinder forces can be in either direction, to extend or retract. Each time the cylinder moves in the direction that retracts or compresses the spring, a portion of the cylinder's force is used to compress the spring. To determine the actuator's net force output, the force to compress the spring must be subtracted from the cylinder's force. When the cylinder moves in the direction that allows the spring to extend, the spring's force can be added to the cylinder's force, to determine the net force output.

However, when sizing the "fail-safe" force for a shut-off condition, we must assume zero pressure in the cylinder, so the spring will be doing all of the work.

SELECTING THE PROPER SPRING

The springs used on REXA actuators are "pre-loaded" so they will apply a minimum force in each case. This pre-loading is done by deflecting the spring a specific amount during assembly. This initial deflection is based on the spring rate and results in the Spring Initial force. Each spring is also designed with a maximum output force at maximum compression height (end of travel); this is referred to as the Spring Final force.

As the cylinder moves in the direction to compress the spring, an increasing amount of the cylinder's force is required to compress the spring. This spring force is calculated by multiplying the spring rate by the travel (additional deflection) plus the spring initial force.

Spring Force = (Spring Rate x Cylinder Travel) + Spring Initial

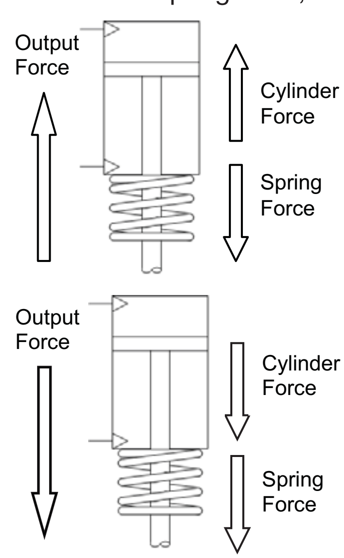
The net output force of an actuator at any point is the cylinder force plus or minus the spring force, depending upon force direction.

When calculating the force in the direction that compresses the spring, we subtract the spring force from the cylinder force.

Actuator Net Output Force = Cylinder Force - Spring Force

When calculating the force in the direction that extends the spring, we can add the spring force to the cylinder force.

Actuator Net Output Force = Cylinder Force + Spring Force



LINEAR SPRING SELECTION

The chart below provides the Spring Rate, Spring Initial and Spring Final forces in pounds for each spring matched to its' appropriate linear cylinder. Use the three steps below the table to select the proper spring for each application.

Linear Spring Selection Chart

Cylinder Force (lb)	**Spring Rate** (lb/in)	**Cylinder Travel** (in)				**Spring Final** (lb)
		0.75	***2***	***4***	***6***	
		Spring Initial (lb)				
2 000	300	1 075	700	—	—	1 300
	180	—	—	580	—	1 300
4 000	195	1 404	1 160	770	380	1 550
	500	—	2 675	1 675	675	3 675
10 000	525	—	1000	—	—	2 050
	500	—	4 750	3 750	2 750	5 750

Note: *The Spring Initial forces in the shaded cells are considered optional "high rate" springs.*

1. Using ***Spring Initial***, determine the lowest cylinder/ spring rate combo that will meet the fail-safe shut-off requirement and provide the required cylinder travel.
2. Subtract the ***Spring Initial*** from the ***Cylinder Force*** to make sure there is sufficient force to initiate travel.
3. Subtract the ***Spring Final*** from the ***Cylinder Force*** to make sure there is sufficient force to fully stroke the application.

LINEAR SHORT-STROKING

On linear actuators, the full rated stroke of the cylinder and spring may not be required in the application. This allows us to adjust the "spring initial" by further pre-loading or additionally pre-compressing the spring. This allows us to get more force out of the spring than the standard chart suggests.

The spring rate is used to determine how much additional force is available in a particular unit. The spring rates listed in the table above represent the amount of force in pounds, required to compress each spring 1 inch. Spring rates are a constant for each spring. This means the "rate" does not change with stroke. The force will always be rate multiplied by distance. In other words, it would require 600 pounds of force to compress a 300 pounds/inch spring 2 inches. When pre-compressing a linear actuator, make sure sufficient stroke remains for the intended application.

EXAMPLE: 1" STROKE APPLICATION THAT REQUIRES 800 LBF

Assume an L2000-2. The Spring Initial is 700 lbf. However, if we set the seated position, such that the spring is pre-compressed ½″ more, we get an additional 150 lbf (300 lbf/inch of stroke × ½″ of stroke = 150 lbf) for a total of 850 lbf.

ROTARY SPRING SELECTION

The chart below provides the Spring Rate, Spring Initial and Spring Final forces in inch-pounds for each spring matched to its' appropriate rotary cylinders. Spring Final force is at a full 90 degree travel. Use the three steps below the table to select the proper spring for each application.

Rotary Spring Selection Chart

Cylinder Torque (lb·in)	**Spring Rate** (lb/90° of rotation)	**Spring Initial** (lb)	**Spring Final** (lb)
2500	625	1000	1625
5000	1250	2000	3250
10000	2500	4000	6500
20000	5000	8000	13000
100000	12500	20000	32500

1. Using ***Spring Initial***, determine the smallest cylinder/spring combo that will meet the fail-safe shut-off requirement.
2. Subtract the ***Spring Initial*** from the ***Cylinder Torque*** to make sure there is sufficient force to initiate travel (break-away-torque).
3. Subtract the ***Spring Final*** from the ***Cylinder Torque*** to make sure there is sufficient force to fully stroke the application.

ROTARY SHORT-STROKING

Rotary actuators generally require the full 90° of rotation, so short stroking is not generally applicable. Please refer to the factory for any rotary short stroke applications.