MECHANICAL SPRING CYLINDERS
A DESIGN PROFILE

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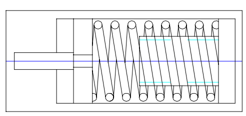
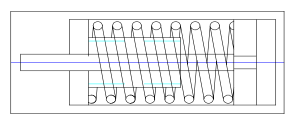
IN GENERAL:

Mechanical spring cylinders have been around the cylinder industry for almost as long as the cylinder industry itself. Spring cylinders are designed to provide the opening or closing force required to move a load to a predetermined point, which is normally considered its "fail safe" point.

Mechanical spring cylinders are either a spring extend, (cylinder will move to the fully extended position when the pressure, either pneumatic or hydraulic, is removed from the rod end port), or a spring retract, (Cylinder will retract to the fully retracted position, again when pressure, either pneumatic or hydraulic is removed from the cap end port).



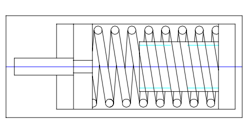
SPRING EXTENDED



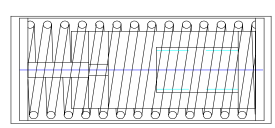
SPRING RETRACTED

Mechanical spring cylinders can be used in any application where it is required, for any reason, to have the cylinder either extend or retract at the loss of input pressure. In most cases a mechanical spring is the only device that can be coupled to a cylinder, either internal or external to the cylinder design, which will always deliver the required designed force at the loss of the input pressure, and retain the predetermined force for as long as the cylinder assembly integrity is retained.

As noted, depending on the application, i.e., space, force required, operating pressure, and cylinder configuration, the spring can be designed to be either installed inside the cylinder, adapted to the linkage connected to the cylinder, or mounted externally on the cylinder itself by proper design methods.



INTERNAL SPRING METHOD



EXTERNAL SPRING METHOD

Applications for the mechanical spring cylinder are unlimited, and are generally used to provide the required load at loss of input pressure. Several important uses include valve cylinders, conveyor shift positioners, damper control cylinders, collating machines, steam control devices, and many many others where the safety of the process stoppage is required at the loss of system power.

DESIGN CONSIDERATIONS:

Designing the mechanical spring cylinder is not a complicated process, but in all cases preliminary information is always required.

1. "Initial Load," the preliminary force required when the cylinder is at rest. This is the force required from the cylinder to keep the application load from moving, with the appropriate safety factor, i.e., a spring cylinder either fully open or fully closed against the required load.

2. Minimum available pressure the cylinder will have available in order to perform its work.

3. Operating medium: Is the system a pneumatic or hydraulic system? Hydraulic systems generally require a higher "initial load" due to cylinder seal friction and hydraulic system internal friction losses, and requirements.

4. Operating stroke required, (actual cylinder stroke). The operating (actual) stroke required will have an effect on the total stroke determined, particularly if a specified low operating pressure is available, or a higher initial load is required, resulting in the longer total stroke.

5. The cylinder and static load force, including linkage loads. These are used in determining the "initial load".

6. The applications load requirement. This is also used in determining the "initial load".

7. The mechanical spring cylinder "over-force factor" to be used. The "over-force factor" is the additional force the cylinder will develop over and above the total working load the cylinder will be required to develop to performed the designed task. In simple terms it is a design safety factor. Normally, the absolute minimum should be at l.3:1. i.e. if the total load "Final Load" of the cylinder, "Initial Load" plus all other forces that give the "Final Load" is determined to be 1000 pounds, the cylinder should develop at least 1300 pounds, to assure the cylinder will be able to operate satisfactorily

Using this required information the "Final Load," (spring load plus application load), can be determined. When determining the "Final Load", the spring rate to be used to obtain the "Final Load " is also determined. The spring rate, normally specified in pounds per inch, is selected or determined by how much load the cylinder will be required to move, and the seven (7) steps as outlined above.

Sometimes the available space for the cylinder may limit the bore size of the cylinder, therefore requiring a lower rate per inch spring to be considered in order to reduce the overall cylinder force developed, resulting in a lower overall "Final Load", which may also result in a longer overall cylinder total stroke.

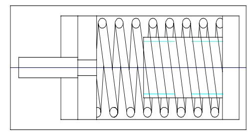
As the required application information is determined, the cylinders final total stroke is developed. A general "rule of thumb" in estimating the total stroke is that the total stroke of a cylinder will be approximately two (2) times the cylinders actual stroke required. But, experience has shown that the total stroke of a cylinder can be as much as six (6) time the actual stroke, depending on the "Initial Load", "Final Load", the operating pressure, and the resulting final bore size of the cylinder .

Also, in general only one spring or perhaps two springs are required to obtain the design forces and meet the requirements of the actual stroke. Here again, experience has shown that as many as four (4) springs operating in series tandem may be required to develop the designed forces within the operating limits set forth by the cylinders operating parameters.

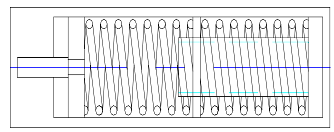
CYLINDER, MECHANICAL SPRING CONFIGURATIONS,(COMPRESSION SPRINGS):

Many mechanical spring configurations are used in spring cylinders, some of which are shown below. Of particular point on coil springs is that the ends of the springs be closed and square ground to assist in preventing “cocking or buckling” of the spring during its compression. When designing the spring extend or spring retract cylinder, always make sure that a spring is not used where is may buckle at any point during its compression.

1. Single coil spring, spring extend.

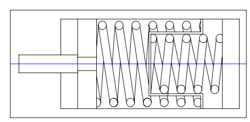


2. Double coil spring, series tandem, spring extend.



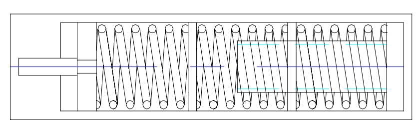
When using the series tandem configuration, it is suggested that a spring spacer be placed between the ends of the springs in order to help maintain a concentric spring column, and also help in preventing spring buckling.

3. Double coil spring, series internal, spring extend.



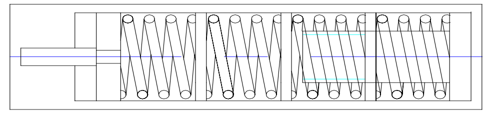
When using springs in series tandem, in order to obtain longer cylinder actual strokes, with reduced spring forces, the total length of the cylinder will sometimes become too long for the available space. One method, internal cylinder space permitting, is to use the double coil spring, series internal. This method of placing one spring inside the other, separated by a “top hat like “ device will provide a spring rate equal to the rates of the two (2) springs divided by 2. This configuration will produce a shorter total cylinder length, and is typically used only on the double coil, series internal configuration. Experience has shown that due to higher costs this system works best with larger bore cylinders i.e., above 10 inch bore.

4. Triple coil spring, series tandem, spring extend.

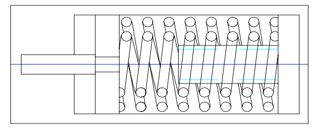


Triple, and Quadruple, series tandem cylinders are used and applied on a very limited basis and generally only when other methods have proven not feasible. Experience has shown them to work where low cylinder operating pressures are available, or higher initial load forces are required for the available pressures, in conjunction with a longer actual stroke requirement.

5. Quadruple coil spring, series tandem, spring extend.

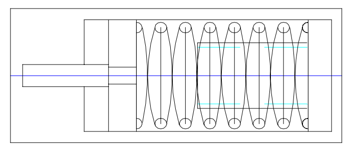


6. Dual spring, parallel, spring extend.



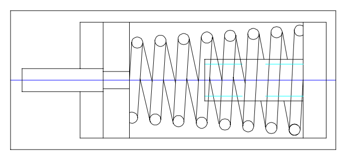
The dual spring, parallel cylinder uses (2) two springs, one inside the other, with counter wound coils to prevent locking during compression. This configuration would be used were it is possible to build the spring forces rapidly, have a higher load capability, and normally will result in a shorter total stroke requirement.

7. Die spring, spring extend.



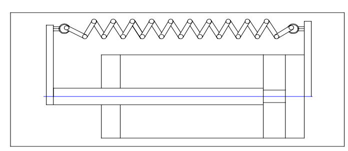
Die spring cylinders are generally short stroke high spring force cylinders primarily used for clamping a load in fixturing type applications.

8. Conical spring, spring extend.



CYLINDER, MECHANICAL SPRING CONFIGURATIONS,(TENSION SPRINGS):

Single tension, spring retract.



Normally, only a single tension spring would be considered and it would be configured as a spring retract cylinder, typically on the outside of the cylinder. Since it is subject to environmental hazards as well a being a potential personnel safety hazard, it may be required to be shielded as determined by health and safety laws.

The preceding drawings show many spring extend cylinder configurations. It should be noted that where space and designs permit, each of the designs may also be configured as a spring retract configuration. The cylinder designer’s experience may be the determining factor in many choices.

CYLINDER DESIGNING:

When designing cylinders to use these different spring configurations, the understanding of spring forces and their uses is mandatory.

1. A single spring provides the forces as delivered by the rate of the individual spring selected. i.e. 25 pound per inch rate spring will provide a force equal to the 25 pound per inch rate times the number of inches the spring is compressed. (therefore 3 inches of spring compression will provide a 75 pound total spring force.

   A design using this spring might be for a 25 pound spring “Initial Load," plus three (3) inches of actual cylinder stroke, giving an additional 75 pounds of force, producing a total spring force of 100 pounds “Final Load”. The cylinder would be designed so that it would have the spring compressed one inch at cylinder assembly. This is typically called “pre-compression.”

2. When the cylinder design requires the consideration for the use of multiple springs in series tandem, the knowledge of what the spring forces produced will be is critical to the design.

   Two (2) identical springs in double series tandem will produce the sum of one-half of the rate of only one of the springs. This is due to the fact that each of the springs is being compressed at only one-half its rate. i.e., two(2) fifty pounds per inch rate springs will produce an effective rate of only 25 pounds per inch. (50/2=25).

   Using these same identical springs in triple series tandem will produce the sum of one-third the rate of one of the springs. Again this is due to the fact that each of the springs is being compressed at only one-third its rate. i.e., 16.66 pounds per inch. (50/3=16.66)

   This procedure would be used accordingly as the number of springs is configured to meet the requirements of the individual applications.

3. When using two springs in a dual, spring parallel configuration, one inside the other with opposite wound coil configurations, (one clockwise and one counterclockwise, which prevents the coils from interlocking during the springs compression), the resulting spring force per inch will be the sum of the two springs rates. An example would then be a spring of 100 pounds per inch combined with a spring of 225 pounds per inch, producing a final rate of the total of 325 pounds per inch.

SPRING, DESIGN LIFE EXPECTANCY:

The design life expectancy of a spring used in a mechanical spring cylinder is a question frequently asked when designing a cylinder with an internal or external spring.

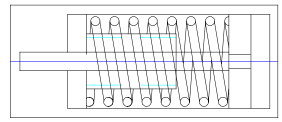
Generally speaking, if the spring is designed to, and operated within its allowable designed yield stress limits, the life of the spring, and consequent life of the cylinder is considered infinite. But, if the spring is subjected to stress beyond its yield stress limits, the closer to those limits it is subjected to, the shorter, more finite its life may be.

When designing the cylinder, it is normal to install a positive internal or external mechanical stop to assure that during cylinder operation the spring is not subjected to being compressed to its solid height, or in the case of a tension spring, stretched beyond its yield stress limits.

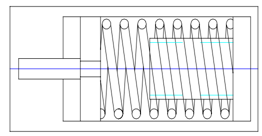
MECHANICAL STOPS:

Several methods of internal spring stops are shown here.

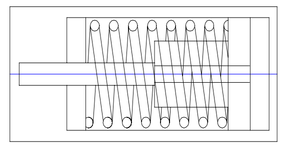
1. Stop tube, head end, spring retract cylinder.



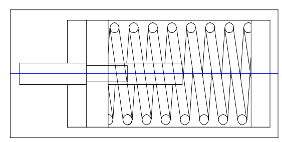
2. Stop tube, cap end, spring extend cylinder.



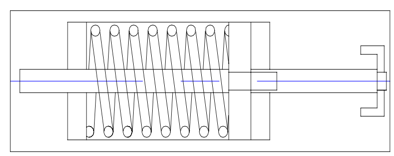
3. Stop collar, head end, spring retract cylinder.



4. Internal stop rod, cap end, spring extend cylinder.



5. External spring stop using a double rod ended cylinder, normally with a spring retract cylinder.



As with any design, other methods can be used. The limitations are only bound by the configurations encountered, and the experience of the individual designer.

MECHANICAL SPRING MATERIALS:

As with any mechanical device, mechanical springs are designed to be manufactured from many materials in order to be used in the various configurations that they will be used in. Several materials are listed below.

1. Spring steels, music wire, hot rolled and hard drawn music wire, and oil tempered wire.

2. Stainless steels, 300 Series, 400 Series, 17-4PH, Condition Hardened, and others.

3. Inconel steel.

4. Hastelloy steel.

5. Beryllium Copper, and Phosphor Bronze

6. and others.

The material selections are influenced by the effects of the proposed cylinder design operating environment and parameters, including spring/cylinder cycle rate and operating temperature.

HEALTH AND SAFETY CONCERNS:

Warning Labels / Tags: When designing spring cylinders, the issue of personnel safety is always of major concern. Spring cylinders can and do store very high amounts of kinetic energy in the "Initial Load" and "Final Loads". Release of these loads in an uncontrolled manner can result in serious personnel injury or death, and also in product or system damage.

It is therefore critical to note on the cylinder with various warning labels / tags and other appropriate measures to assure that the cylinder is not disassembled without the necessary tools and equipment to prevent personnel injury / product damage. Product labels / tags alert personnel to the potential hazard inside the cylinders .

Assembly / Disassembly Procedures: Where the warning labels / tags alert personnel to the potential hazards , product assembly and disassembly procedures instruct them in the proper manner for the cylinders assembly and disassembly.

These procedures should contain sufficient information and illustrations to properly inform the repair personnel to all of the potential hazards that they may encounter during the disassembly and assembly of the cylinder.