

Spring Materials and Design Philosophy

[from Superior Shooting Systems Inc.]

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Springs are perhaps the most overlooked component in the performance of any rifle, pistol, or shotgun. If the spring does not perform adequately, then the firearm will not perform to its full capabilities regardless of the firearm's price, quality, or workmanship.

Honestly, one reason is that the extra cost of Chrome Silicon springs scares some manufacturers away when they are preparing to purchase hundreds of thousands of springs for a run of firearms or components. Many manufacturers don't seem to put much value on the continued high performance of their firearms, but rather focus on their bottom line. Superior Shooting Systems Inc. steps in to provide the shooter with lifetime performance springs.

Through the years a common question has been just how often springs should be changed. There are many factors which influence longevity, but, as a rule of thumb, a spring should be replaced when it has lost 10% of its efficiency (load) at its working height. In the case of most gun springs, this is derived when the spring is installed and then measured at a specific compression height.

Unfortunately, many shooters do not change their springs on a timely basis because the firearm still functions. This is the equivalent of running an automobile engine with 3 quarts of oil instead of 5. It still works, but the gun's life span has been greatly impaired because of extra stresses now imparted on the rest of the firearm's working parts.

Although the comments made in the following material may be directed at a specific firearm, it can all be applied consistently to other types of firearms. This is by no means a definitive treatise on springs, but is written in simple terms to provide some basic knowledge of springs and spring design considerations.

Longevity

How long should a spring last? Obviously there many factors that determine how many compression cycles a spring can withstand before it loses its efficiency. Here are a couple of points to consider:

1. In the 2002 running of the Rolex® 24 Hours of Daytona, the valve springs in the winning car underwent more than 15,000,000 compression cycles during the course of the race. This does not include any additional run time the motor was subjected to prior to the beginning of the race.
2. In a typical Indianapolis 500, the valve springs in the winning car will undergo almost 3,000,000 compression cycles in a 2 to 3 hour time span. One thing both these applications have in common is that they use CHROME SILICON wire for the valve springs.

Recently Superior Shooting Systems Inc. did a quote on a helical compression spring (minigun) for a military application. The original blueprint that was provided called for a minimum of 100,000 operations (compression cycles) with no permanent set or damage/injury to the spring. Taking advantage of new technology and material? NOT HARDLY! The blueprint had an original drawing date of 25 September 1969. The specified material was a stainless alloy spring. As a note of interest, the blueprint specified only that the springs be COLD SET.

When we quoted the aforementioned springs, we did so using chrome silicon wire. Our chrome silicon springs are HEAT TREATED, SHOT PEENED, and STRESS RELIEVED as

part of a comprehensive post-winding processing program. After these processes, the spring is now a different breed of cat. This spring now has the ability to withstand an unbelievably harsher environment due to these post winding processes. Our calculations showed that with this change in material (chrome silicon is superior to the stainless alloy, and both exhibit the same corrosion resistance) coupled with the proper post-winding processing, in the case of the helical compression spring (minigun) the life span of this spring is increased by a minimum factor of 10. We further stated that the spring should lose no more than a maximum of 7% efficiency through 1,000,000 compression cycles although we felt that the useful life would ultimately be somewhat higher (2,500,000 cycles) with an actual loss of efficiency in the 3 to 4% range in the first 1,000,000 cycles.

These above examples are cited to illustrate that springs of high longevity and efficiency are not illusory or a product of some brand new technology. It really illustrates the fact that, for whatever reason, available existing technology has not made its way to the firearms industry -- until now.

SPRING TERMS GLOSSARY –

Free length: the measurement end to end of a spring under no load

Installed height: the measurement end to end of a spring as installed in its application

Solid height: the measurement end to end of a spring at its maximum compression

Spring Basics 101

As a rule of thumb, for a normal (music wire) spring to have a reasonable life span (say 5000 compressions), the coiling stress should not exceed 60% of material tensile strength (at first yield) whereas with Chrome Silicon the coiling stress can be as high 75%. This is true regardless of the application. To quote from a spring design text: "Choosing the correct material for spring applications is as critical as the spring design itself."

Along with the coiling-stress/tensile-strength ratio is the amount of total deflection of the spring's operation. "Deflection" is the amount that the spring compresses. Total deflection is the total compression measurement from free length to solid height. In an AR15 (standard length buffer tube) the installed height of the buffer spring is approximately 9.427 inches, the deflection at installed height (in battery) is the free length minus the installed height. Thus if the spring had a free length of 12.625 inches, the deflection at installed height would be 3.198 inches. In our case, this determines the load that the spring exerts when the AR15 is in battery (amount of deflection times linear compression rate).

Coiling stress is stress that is imparted to the material as the spring is wound and is expressed in PSI (pounds per square inches) or as a stress factor multiple of the tensile strength of the material. Coiling stress is affected by a number of factors, but for our purposes the explanation is simple: the thicker the wire, the higher the coiling stress when comparing two similarly designed springs. The coiling stress in an 11 lb. buffer spring is lower than the coiling stress in an 18 lb. buffer spring. Coiling stress is generally measured at two positions as part of the engineering/design work: in the case of an AR15 rifle it is the installed height and the solid height.

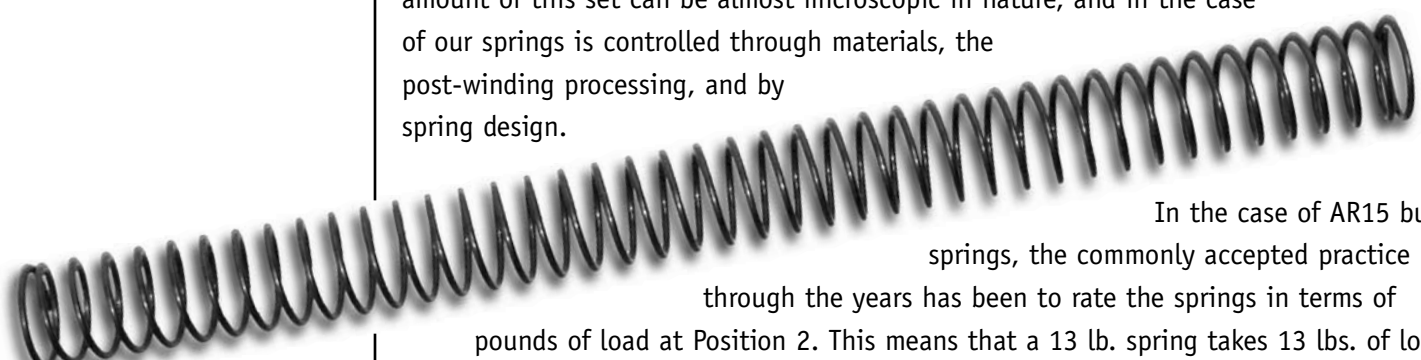
Material tensile strength is important, but too many times people tend to concentrate on it as an end all, cure all. Tensile strength is a function of wire diameter. The thicker

the wire, the lower the tensile strength. This is true for virtually all spring materials.

Another major factor is the first “yield point” of the material. This is the point at which the spring and material will yield to outside pressures and not fully relax. That is to say, when a spring reaches and then exceeds its first yield it will no longer come back to its pre-compression length. This contributes significantly to both initial spring set and continual spring set. Typically, high grade alloys have a higher first yield point than lower grade materials, which is one of the factors in minimizing spring set. This yield point is also a function of the amount of the deflection of the spring at Position 2, which, in the case of an AR15, is when the carrier is at its full rearward position (under recoil). (Position 1 is the installed height.) Generally, with music wire the first yield will occur at about 80% of total deflection.

As to spring set, let's clear up some basic misunderstandings.

- 1.) ALL SPRINGS (including our CS Springs) will take a set.
- 2.) A spring does not take a set and then stabilize with no further deterioration in function unless its operating conditions and parameters have been changed to reduce stresses imparted to the spring. If a spring stabilized (as some claim), then it would never wear out because it would have no further reduction in its operational loadings after the initial set.
- 3.) All springs continue to take an additional set with every compression cycle. The amount of this set can be almost microscopic in nature, and in the case of our springs is controlled through materials, the post-winding processing, and by spring design.



In the case of AR15 buffer springs, the commonly accepted practice through the years has been to rate the springs in terms of pounds of load at Position 2. This means that a 13 lb. spring takes 13 lbs. of load to compress it to Position 2 (which is solid height or nearly solid height). [I know that Wolff® does not rate their springs at total deflection or solid height.] The problem with this, which is magnified through the use of readily available and inexpensive spring testers, is that the aforementioned 13 lb. spring could lose an inch of free length (this can happen in fewer than 350 compressions), which then significantly decreases its load at Position 1 (in battery) but it still requires 13 lbs. of load to compress it to Position 2. This is true regardless of the material used to wind the spring. ALSO, spring testers are subject to inconsistent operator operation, and, further, make no allowances for a mechanical property of springs known as “histrionics.”

Materials

As cited previously, sometimes the material is more important than the design. We will touch on some basic differences between music wire and chrome silicon wire.

Music wire is a basic staple of the spring industry. It provides good tensile properties

A SpeedLock™ CS Firing Pin Spring provides a performance enhancement no other spring can claim, and it will do so for a minimum expense (to say nothing of never having to purchase another spring for that rifle).

and has good corrosion resistance. Further, it is easily formed (read: CHEAP TO MAKE) and is generally the easiest of the spring wires to work with. Just as with other spring materials, there are varying grades of music wire. In general, music wire displays a propensity for wide variations in mechanical properties from bulk lot to bulk lot. This can lead to inconsistent spring performance.

This variance is demonstrated most commonly in the free length of music wire springs that are manufactured from different lots of material. When a variance in the material is encountered and the design parameters call for a given load at solid height, the free length of the spring is changed to accommodate this variance in the properties of the material. That is, you may purchase two 13 lb. buffer springs of the same manufacture from different sources (thus probably from different lots of material) and have them vary considerably in free length, but if tested, will both require 13 lbs. of load to compress to solid height. In springs that we acquired for testing, we measured more than one inch difference in free lengths. This is not to imply poor quality control because the springs tested right on the money at solid height. However, there was a significant variance in the load exerted at installed or in-battery height.

Because of the properties of music wire, virtually no post-winding processing can be performed to enhance the physical properties of the material or of the finished spring. Music wire has a maximum service temperature of 250°F and can be negatively affected at temperatures as low as 175°F. As a spring approaches its maximum service temperature the heat affects the spring primarily in two ways: 1.) The heat promotes additional spring set, and, 2.) the heat is detrimental to the relaxation of the spring. In other words, the spring just does not decompress as rapidly as it was originally designed to do.

Superior Shooting Systems Inc. uses certified aerospace specification chrome silicon wire for all SpeedLock™ CS springs it manufactures. By using certified materials, this allows our springs to be manufactured with consistent properties without regard to the lot of material from which the spring is wound.

SpeedLock™ CS springs are then heat-treated, shot-peened, and stress-relieved as part of a comprehensive post-winding process to enhance grain structure, promote maximum longevity, and provide consistent performance. Our springs are stress relieved at 800°F to 825°F. The maximum service temperature of our materials is far in excess of that to which they will be subjected in any firearm. All of this is done to minimize spring set and maximize spring durability.

Spring Design

SpeedLock™ CS springs are different by design. Our basic philosophy is that 90% of everything that is important in a firearm happens when the gun is in battery.

Once the bolt unlocks and begins to move, the only important function of the spring that remains is to return the bolt with enough force to strip and chamber the next round.

To this end, SpeedLock™ CS springs are designed to maximize in-battery time at the lowest possible linear compression rate for a given spring. Because the “weight rating” method used by Wolff® has become so firmly entrenched, we decided that it would be easier to use that as an indicator of compatibility for SpeedLock™ CS springs rather than

Our SpeedLock™ CS Spring can do as much as 75 percent more work than a comparable music wire spring, and it can do so at a lower linear compression rate over the total deflection of the spring. This is why we say in our literature that a SpeedLock™ CS spring performs like an “extra power” spring but does so at a lighter weight. It’s true!

try to change everyone’s thought processes. So, this is where spring testers come back into play. The SpeedLock™ CS spring will not measure the same as a music wire spring. However, this same SpeedLock™ CS spring will exert a significantly higher load in battery than the comparable music wire spring, especially after usage, and, in some cases, just after installation. How much? It would be fair to say that after only 500 rounds, the SpeedLock™ CS spring probably exerts a minimum of 20% more load in battery than a music wire spring.

A Goodman Diagram as used in most spring design CAD software shows that our springs can do as much as 75% more work than a comparable music wire spring and do so at a lower linear compression rate over the total deflection of the spring. Talk about having your cake and eating it too!

The importance of transferring energy to the spring as early and as much as possible is simple. Reduce bolt velocity to minimize energy transfer to the firearm when the bolt stops its rearward travel. Basic physics come into play: When velocity increases, the energy imparted to the mass accelerated increases by a factor of 4. If a worn-out spring creates a velocity increase of 10%, the energy increases by 40%.

Because of our design, the lower linear compression rate reduces that same effect of mass that the bolt carrier imparts when it closes. This allows the shooter to recover more quickly between shots because he is not encountering erratic sight movement as the gun comes back into battery. The difference in feel of an AR15, for instance, is quite noticeable with one of our SpeedLock™ CS Buffer Springs installed. Likewise, something like a Winchester® Model 70™ will show faster lock time, a lighter trigger, and lower bolt lift effort.

Summary

Current music wire spring technology is virtually the same now as it was 100 years ago when John Browning was designing firearms. Superior Shooting Systems Inc. has brought state-of-the-art manufacturing, design, and materials to the shooting public. We intend our products to provide maximum performance and consistent function.

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