Restoring a Mid-Year Rear Leaf Spring: Combining the Best of Old and New

by

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When I wrote my first article on the 1963-1977 rear leaf spring (see Vol. 26, No.3, p. 12-16) I concluded by saying that I planned to perform a purely cosmetic restoration of an original, but used, 9-leaf spring when restoring the rear suspension on my 1966 small block coupe. After disassembling the candidate spring I found that there was more corrosion and pitting on the main leaf than I had first noticed and since the main leaf is the most noticeable leaf and the most important leaf from a structural and safety perspective, I decided to reexamine my options. This article is a chronicle of that reexamination.

When restoring a mid-year rear spring both function and appearance are important for those who drive and show their cars. For the 9-leaf mid-year spring, getting both the function and the appearance correct isn't necessarily that easy. As is the case with many mid-year parts, GM discontinued the mid-year, 9-leaf spring long ago. Thus one has the option of restoring a used spring or buying a new reproduction spring. If restoring a used spring is one's choice, the cosmetic restoration is straightforward, but one is left with the uncertainty concerning the spring's structural integrity. After 35 years of use a typical leaf spring will have experienced hundreds of thousands, if not millions, of loading cycles resulting in fatigue damage and more than 300,000 hours of static loading resulting in creep damage to the spring material. Fatigue damage typically exists in the form of cracks ranging in size from microscopic to those that can be seen with the naked eye. Creep damage is the slow, progressive, and permanent deformation that occurs when a material is subjected to a constant load for a long time. Creep damage in a spring is evident when the spring loses its arch.

Restoring a used spring naturally brings up the issue of re-arching. While having a spring re-arched can alleviate creep deformation and return a spring to its original arch, re-arching will not remove fatigue damage in the form of cracks because the temperatures used during re-arching are not high enough to remelt the steel. Re-arching involves heating each leaf to a temperature of approximately 1650 degrees F, significantly lower than the steel's melting temperature of approximately 2700 degrees. After heating, the red-hot leaf is formed to the correct arch and quenched in oil. After quenching, the leaf is returned to the oven for tempering. In addition to its inability to repair pre-existing fatigue cracks, the re-arching process will also eliminate the beneficial effect of an important manufacturing step, namely shot peening. In the design of its mid-year leaf springs, GM specified that the tension surface of each leaf was shot peened. Shot peening introduces compressive residual stresses in a thin surface layer on the side of the leaf that will be subjected to tensile stresses during service. These compressive residual stresses lower the effective tensile service stress, thereby increasing the fatigue life of each leaf. The heat treatment during re-arching will eliminate these beneficial compressive stresses. Be advised that some spring re-archers do not have the capabilities to perform the shot peening operation. Re-arching is not a good solution if the candidate spring has significant fatigue damage. Unfortunately, even without the presence of visible cracks it's hard to know how much fatigue damage exists in a spring. Improper re-arching technique or the use of a spring with excessive fatigue damage is likely to result in a re-arched spring that either breaks or does not maintain its arch.

For those readers who remember Larry McCarty's 1979 article in the Restorer (Vol. 6, No. 1, p. 20), the mechanical, brute force (i.e., large hammer) approach to re-arching suffers from the same primary shortcoming as the heat treatment approach, i.e., neither re-arching technique will eliminate pre-existing fatigue damage. In addition, sufficient information is not available to the general public to accurately re-arch a spring on one's own. The design specifications for each individual leaf are privileged information (available to GM and members of the Spring Research institute) and therefore there is no way for most of us to know how much each leaf needs to be re-arched. In my opinion, re-arching should be left to the professionals and should be considered only as a last resort.

Since the rear spring plays such an important structural role, many people opt for buying a new reproduction spring. Unfortunately, this choice can lead to two problems: 1) currently available reproduction springs differ cosmetically from original springs; and 2) a common complaint about reproduction springs is that they result in an increase in ride height.

For those people interesting in having their cars judged, the appearance of the spring is a major concern. There are at least three details where reproduction springs may differ from original springs. The first concerns the ends of the main leaf or leaf #1. This leaf should be trimmed at a 45 degree angle on each corner as shown in Fig. 1 (left). While some reproduction springs are trimmed at the correct angle, others are not. A typically incorrect end treatment is shown in Fig.1 (right).

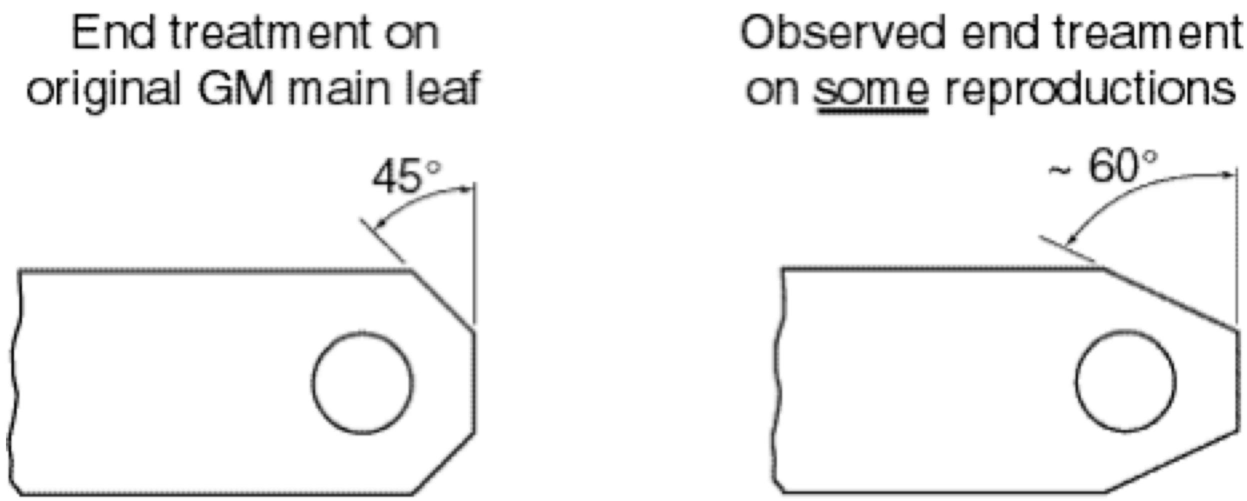

Figure 1

The second detail where reproduction springs may differ cosmetically from originals is in the thickness of each leaf. Using the 1963 leaf spring as an example, the nominal thickness specified by GM is 0.214" for leaves 1-3 and 0.194" for leaves 6-9. Recently I acquired a new reproduction spring advertised for mid-year cars that had a nominal thickness of 0.237" for each and every leaf. The combined thickness of this assembled reproduction spring was 0.3" thicker at the center bolt than my original spring. I don't know if a discerning judge would detect this difference with the spring installed on a car, but with the original and reproduction springs placed side by side, the total difference in thickness is obvious.

The third aspect where reproduction springs differ cosmetically from originals concerns the end treatment for leaves 2-9. The end treatment for leaves 2-9 for an original spring is shown in the sketch in Fig. 2 (left). An example of an incorrect end treatment for a currently available reproduction spring is shown in Fig. 2 (right). To my knowledge no currently available reproduction spring has the correct end treatment for leaves 2-9. Even though the differences between the reproduction and original end treatments in Fig. 2 may seem subtle, they will be obvious to an experienced judge even without having an original spring available for comparison. I think it is also fair to say that it is beyond the capabilities of most of us to alter the end treatment on a reproduction spring to look like the end treatment on an original spring.

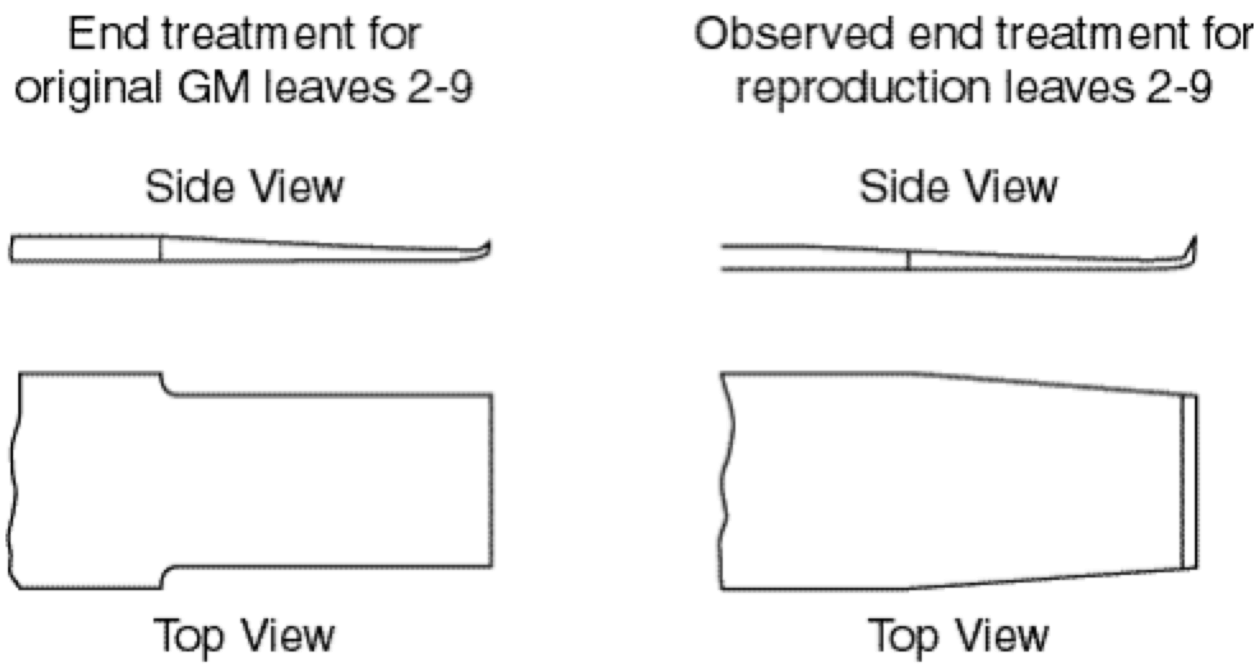

Figure 2

The above cosmetic details are primarily of interest to those people who plan to have their cars judged. For others, these cosmetic issues may be of little or no concern. What does concern many people even if their cars are not to judged, however, is the increase in ride height that occurs after installing some reproduction springs. In this case, it is the structural design of the spring that is the source of the problem.

Three factors affect ride height. These are: 1) the combined thickness of the leaves; 2) the free arch of the spring when it is unloaded; and 3) the deformation of the spring under normal load or design load. To determine the deformation of the spring under load, I tested three different springs by loading them to 1,400 lb using a servo-hydraulic testing machine. (To those adventurous and curious readers, the answer is no, I know of no way to safely test a spring in one's garage.) The three springs I tested included: 1) an original, used 9-leaf spring (GM part # 3850839) that I bought from a local Corvette dismantler; 2) a new reproduction 9-leaf spring that was advertised as the correct replacement for standard suspension mid-year cars; and 3) a hybrid spring that I created using the main leaf from the reproduction spring and leaves 2-9 from the used GM spring. The results of these tests are shown in Fig. 3 and summarized in Table 1.

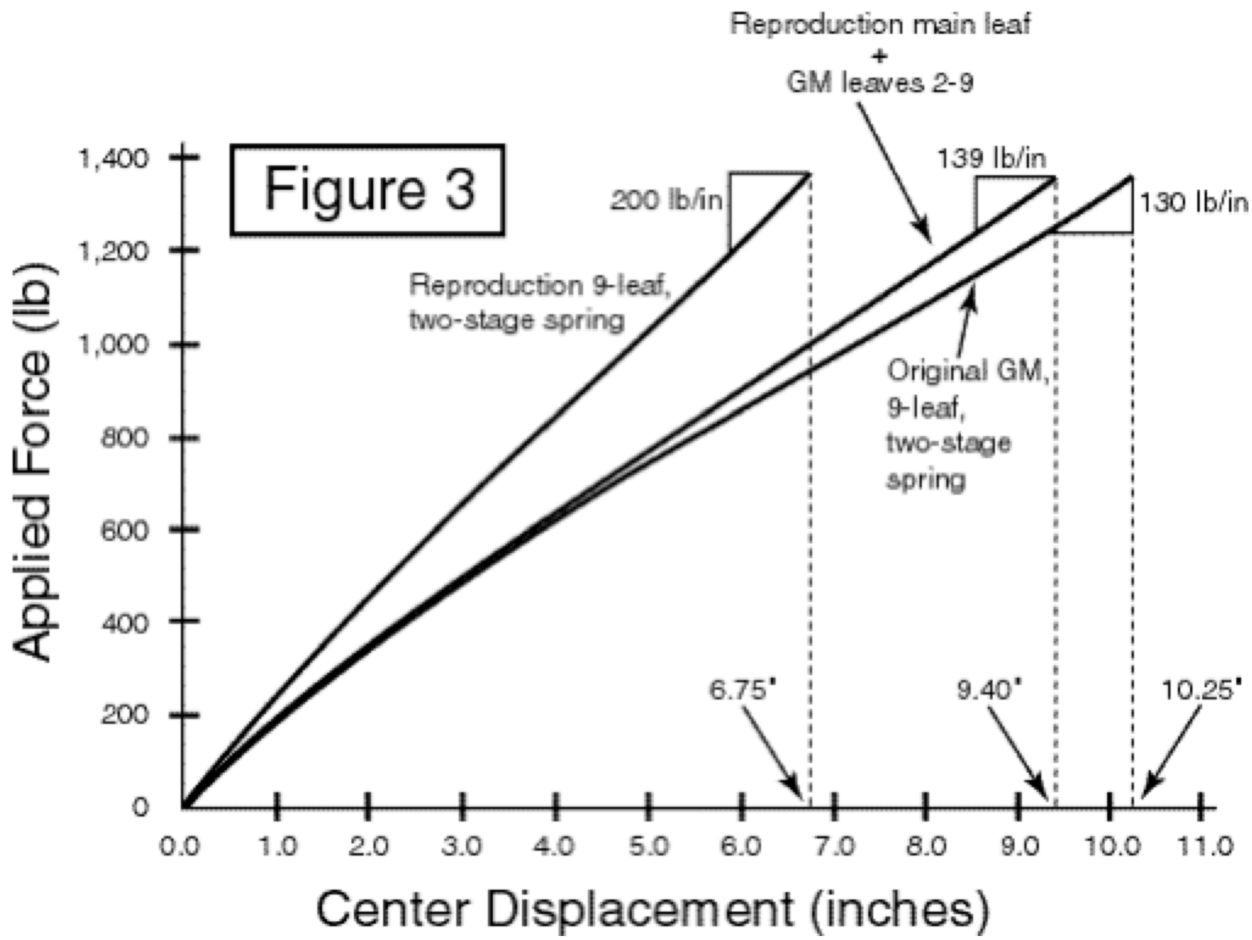

Table 1 Comparison of spring testing data

Description	Free Arch	Stiffness @ Design Load of 1360 lb	Disp. @ Design Load	Change in Height Relative to AMA Specs
1966 AMA Specs	10.0″	140 lb/in	10.352″	N/A
Used GM Spring	10.0″	130 lb/in	10.25″	+ 0.10″
New Repro Spring	8.0″	200 lb/in	6.75″	+ 1.90″
New Repro leaf #1 + GM 2-9	9.25″	139 lb/in	9.40″	+ 0.22″

A few comments are warranted concerning Table 1. First of all, the design tolerance for spring stiffness for a spring of this type would typically be ± 10 lb/in. This means that the spring stiffness could vary between 130 lb/in and 150 lb/in and still be within GM specifications. Thus the used GM spring in Table 1 is within specifications, which it should be unless it had significant fatigue damage in the form of cracks. Secondly, the column labeled "Change in Height Relative to AMA Specs" is related to the expected change in ride height, but the two are not equivalent. My tests were conducted under minimally clamped conditions, while the spring anchor plate in the car creates more clamping at the center of the spring that would reduce the displacement at the design load in comparison to what I measured. It is fair to say, however, that for the particular reproduction spring tested, the combination of a free arch that is too small and leaves that are too thick results in a spring that will cause an increase in ride height. Although I have not tested other reproduction springs, deviations from original GM specifications in spring stiffness and free arch must be the cause of the changes in ride height that are the bane of people who replace their original rear spring with a reproduction unit. My final comment concerning Table 1 is that an increase in ride height of 0.10" or 0.22" is probably not obvious. After all, ride height will differ by at least this much when going from a full to an empty tank of gas.

In conclusion, for those people who are concerned about spring cosmetics, ride height and spring stiffness, one can utilize a new reproduction main leaf and a good set of used leaves 2-9 to produce a restored spring that will look and function like the one that came on your car when it was new. An advantage of replacing the main leaf with a new reproduction main leaf is that this represents a much safer option than cosmetically restoring an old main leaf. The main leaf is the one that breaks most often in a fatigued leaf spring and I guarantee that you don't want to be travelling down the highway at 65 mph and have the main leaf fail.

The key to success in using an old spring is locating a spring in good condition at a reasonable price. The used spring I bought came from a local Corvette dismantler and cost me $45. I've talked with others who have bought used mid-year springs at Carlisle for $50-$75. Used springs are also available from a few of the Corvette catalog companies, but unfortunately they often cost $100 or more plus the costs of shipping. When you inspect a spring make sure there is no pitting or obvious cracks and check that the free arch is close to 10". Also make sure that the end treatments on leaves 2-9 are correct. You don't want to buy a used reproduction spring by mistake.

One important point to make regarding the purchase of a new reproduction spring is that not all 9-leaf, standard suspension, reproduction springs are equivalent. Some Corvette catalog companies claim that a 300 lb/in spring is the correct replacement for standard suspension, mid-year cars. As my previous article explains, this is incorrect. If indeed some of the reproduction 9-leaf springs being sold have a stiffness of 300 lb/in, then the main leaf of these springs is almost certainly thicker than the 0.237" of the reproduction spring that I tested for this article. If you use a main leaf thicker than 0.237" when restoring your mid-year spring, the resulting spring stiffness will be slightly greater and the ride height will be slightly increased relative to the values that I show in Table 1.

Finally, bear in mind that most companies may not be willing to dismantle an assembled spring just to sell the main leaf. If you have to buy an entire reproduction spring, at least you'll wind up with a set of new liners in the process. Combining the best of old and new is definitely going to cost more and take longer than simply settling for a reproduction spring, but I think those of you who care about looks and function will be much happier with the final result.

I would like to end by thanking John Thomson of the Spring Research Institute and Andy Deahl of Betts Spring Company for their willingness to share with me some of their vast knowledge of leaf spring design and re-arching procedures. I'd also like to thank Dan Materazzi for sending me a copy of Larry McCarty's 1979 article on re-arching and to Scott Yerby for his invaluable assistance with mechanical testing.

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