



*This article is provided by FMES for your interest thanks to the kindness of the original publishers. FMES makes no representations or warranties of any kind, express or implied about the completeness, accuracy or reliability with respect to this document and any sentiments expressed are not necessarily supported by FMES. Any reliance you place on this document is therefore strictly at your own risk*

## Coil Springs

This document was written by Peter Gardner and was originally published by Frimley and Ascot Locomotive Club in February 2004.

### Theory:

The two characteristics we need to control are firstly, the stiffness – i.e. how much force at what deflection, and secondly the resilience – i.e. whether the spring will take a set at the peak working load. Most commercial compression springs, when fully compressed, are operating within the safe working load, which helps in extrapolation.

Looking at the stiffness, the force required in order to produce a given deflection or the weight carried is proportional to

- $D^4$  (d = diameter of the wire)
- $1/D^3$  (D = diameter of the coil)
- $1/N$  (N = the number of turns in the spring)

To save arithmetic, from differential calculus, it is accurate enough say that

- for each 1% *increase* in 'd', the force *increases* by 4% and vice versa
- for each 1% *increase* in D, the force *reduces* by 3% and vice versa
- for each 1% *increase* in number of coils, the force *reduces* by 1% and vice versa

You can see from this that there are many ways of getting a spring of a given stiffness and the two other factors which will let you focus in on to the right one are the overall length which the installation requires and the maximum working load or resilience. For vehicle suspension, the deflection will usually be half the axle box travel.

Looking at the resilience, the maximum load is proportional to

- $D^3$
- $1/D$

Again, to save arithmetic we can measure the force needed to fully compress our sample and then

- for each 1% *increase* in d, the maximum load *increases* by 3% and
- for each 1% *increase* in D, the maximum load *reduces* by 1% .

As long as the safe working load is great enough, then things are OK. A good figure for safe working load in the case of vehicle suspension is twice the normal load.

## **Practical aspects**

I measure the characteristics of springs using the kitchen scales and pushing down until the required deflection is observed. The same result can be achieved using a spring balance working a hooked pin through a fixed frame.

Springs can be made using piano wire, obtainable from model aircraft suppliers, and without any further heat treatment. Wind on to a rod held in the three jaw and running at the slowest speed; you may need to support the end of the rod in a female centre (a bit of brass rod centre-drilled) held in the tail-stock chuck. I can usually control the coil spacing by eye with a gloved hand but if in doubt, use the appropriate screw-cutting rate and let the saddle movement guide you or even use a tool post mounted guide made from a bit of wood with a hole in it. Stainless wire is advisable for safety valves as phosphor bronze characteristics deteriorate at boiler temperature. The force on the spring is the maximum pressure times the area of the valve aperture. The deflection is the amount the spring is compressed with the adjusting nut at its normal position.