

Firestone

***World's Number 1
Air Spring.***



FIRESTONE INDUSTRIAL PRODUCTS COMPANY

How an Air Spring Works

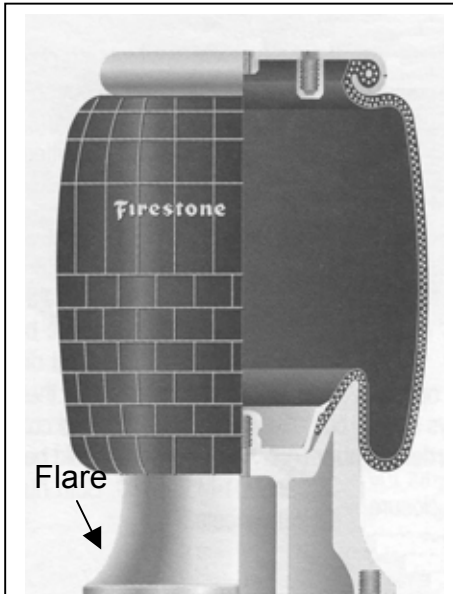
**Paul Koeske
Senior Engineer
Heavy Duty Development**

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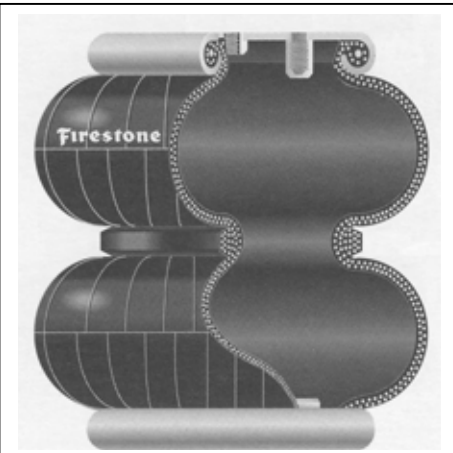
1. Background

Traditional thought in vehicle suspensions many times comes to steel leaf and steel coil springs, but there is another option than bending steel to isolate road disturbances from the vehicle: air springs. Along with efficiently providing vibration isolation, air springs offer many other user-friendly advantages over traditional steel springs.

2. Basic Principles



Reversible Sleeve



Convoluted

There are two basic types of air springs used in vehicle suspensions: reversible sleeve and convoluted. Regardless of whether an air spring is a reversible sleeve or convoluted style it will operate on the same principle; when a volume of gas confined within a container is compressed, it produces a reaction force In the case of air springs the gas is air and the container is a sealed fabric-reinforced rubber bellows or sleeve. Similar to a ball inflated with air, the load an air spring will carry depends on its diameter, and therefore the area of the column of air supported, and the pressure of air inside it. The two basic relationships used in determining the load carrying capability of an air spring are:

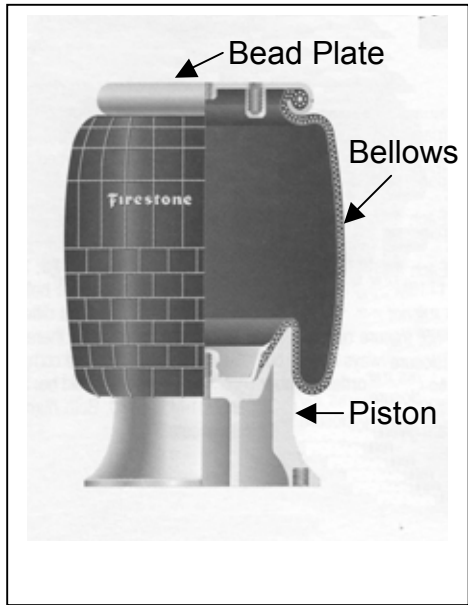
$$force = pressure \times area \quad (1)$$

$$area = \pi \times \frac{diameter^2}{4}$$

From the relationships above, it can be seen that increasing the load an air spring can carry, can be accomplished by increasing the pressure inside the air spring, increasing the diameter of the air spring (and therefore increasing the area) or both. The ability to change the load carrying capacity simply by changing the air pressure rather than changing out the air spring is a major advantage that air springs have over steel springs.

Because an air spring consists of a closed volume of air, the compression of the air spring (jounce travel) will cause an increase in pressure, while the extension of the air spring (rebound travel) will cause a decrease in pressure. This allows the air spring to have an automatic tendency to return to the neutral, or design, height it is set to ride at as it experiences disturbances in the driving surface. The dynamic build-up in compression also helps protect against “bottoming out” and can be further increased on the reversible sleeve air spring by the addition of a “flare” at the bottom of the piston.

3. Components



Although the basic principle behind both the reversible sleeve and convoluted air springs are the same, there are some subtle differences between them. Most notably, the reversible sleeve air spring has a piston which is an additional component that the convoluted air spring does not have. The piston is the component that is fastened to the moving trailing arm or axle mount and as a result plunges in and out of the air cavity within the rubber bellows. In general, a piston gives the reversible sleeve air spring an advantage over the convoluted air spring in that spring rates can be further tuned using a variety of piston profiles. For straight-sided pistons, the reversible sleeve air spring has an advantage over the convoluted air spring in that a constant load for a given internal pressure may be maintained over a range of heights.

The other two major components of an air spring are the bead plate(s) and the fabric-reinforced rubber bellows or sleeve. The bead plate allows for a rigid attachment to the mounting surface(s) and the bellow is the dynamically functioning suspension component that contains the air.

4. Advantages

The main advantages of an air spring over its steel leaf and coil counterparts are:

- Variable load-carrying capability
- Adjustable spring rate
- User-friendly height control
- Low friction action

4.1 Variable Load-carrying Capability

As already mentioned, the load an air spring can carry can be adjusted over a wide range, without changing the air spring height, simply by changing the air pressure. Traditional steel springs need to be replaced if the height must be maintained.

4.2 Adjustable Spring Rate

In addition to changing the load-carrying capability, a change in air pressure will also afford the benefit of changing the spring rate without changing the height and without a significant change in the natural frequency. Steel springs exhibit one spring rate for a given height and, once again, will need to be replaced if the height must be maintained.

4.3 User-friendly Height Control

Using air pressure from the compressor, the air spring height can be maintained by a closed loop control system or adjusted to other desired heights. This allows for “load leveling” and “squatting” capabilities that steel springs cannot offer.

4.4 Low Friction Action

Because there is a flexible rubber member separating the rigid attachment points to the frame and suspension, there is freedom to move about all six degrees of freedom without the resistance and squeaks experienced by the rigid interactions characteristic of steel leaf and coil springs.