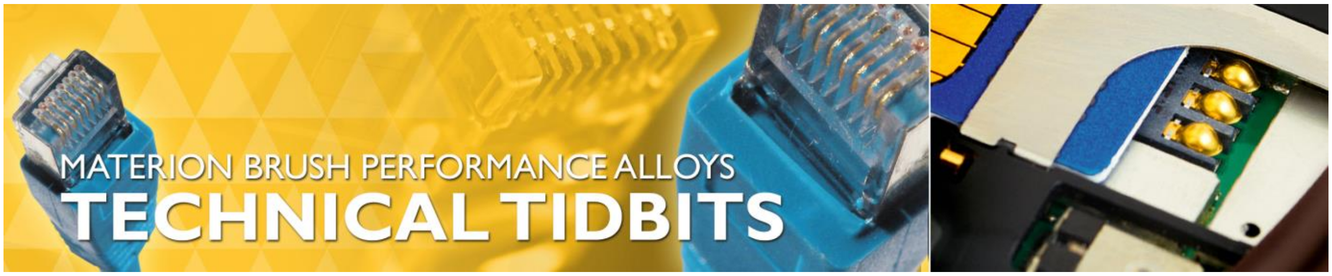


Issue No. 76 – April 2015 **New Publication**

Arch Supports – Contact springs that are functionally equivalent to the simply supported beam.

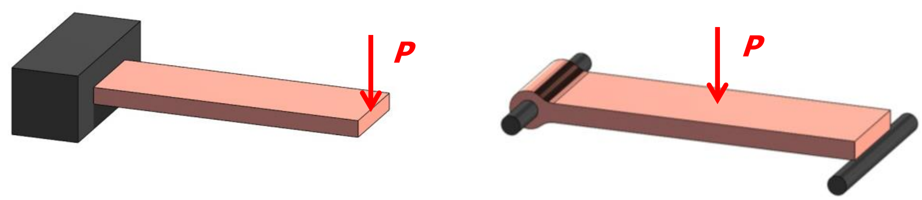
- **Simply Supported / Arch Beam**
- **One-Piece Terminal Socket**
- **Two Piece Terminal Socket**

The next issue of Technical Tidbits will examine springs that are in the form of torsion bars (such as louvered contacts).

Spring Types Part 2- Simply Supported Beams

This series of six or so editions of Technical Tidbits will discuss various types of springs used in electrical contacts or sensors, and group them into six broad categories of similar function (cantilever beams, simply supported beams, torsion bars, Belleville washers, coil springs, and bellows & diaphragms). This month we will focus on the simply supported beam.

The **simply supported beam** (or **arch beam**) is another simple spring type, and is a close relative of the cantilever beam. While the cantilever beam is completely fixed (all 6 degrees of freedom) at one end and completely free at the other, the simply supported beam is hinged at one end, while the other end is supported only in the direction normal to the spring face, while free to rotate and move in the other two directions. While the classical simply supported beam (Figure 1) is a flat rectangle, working springs tend to be curved or arched up toward the applied force or pressure load (Figure 2).



Modulus of Elasticity, deflection, beam width, beam thickness, beam length

$$P = \frac{dEwt^3}{4l^3}$$

Normal Force

$$P = \frac{4dEwt^3}{l^3}$$

$$\sigma_{Max} = \frac{3dEt}{2l^2}$$

Maximum Stress

$$\sigma_{Max} = \frac{6dEt}{l^2}$$

Figure 2. Cantilever Beam vs Simply Supported Beam Spring Type and Relevant Equations for Rectangular Cross Sections.

The ideal cantilever beam is deflected at the free end, and the ideal simply supported beam is deflected at dead center of the length. Note that these equations are valid only as long as the stress is linear and elastic (σ_{Max} < yield strength), and small angle assumptions apply (the deflection is relatively small, on the order of the thickness, so sin $\theta \approx \theta$ and cos $\theta \approx 1$).

A quick look at the equations above reveals something interesting. The equations for both beam types have the same form and the same variables for force and stress. However, note that for the same length, width, thickness and deflection, the simply supported beam provides 16 times the contact force that the cantilever beam does, while experiencing only 4 times the stress.

Arch beam contacts will thus be able to achieve much higher contact forces than cantilever beam springs in the same space. The downside is that simply supported spring contacts have to be stamped separately from the rest of the socket, whereas cantilevered springs can be stamped as part of the socket. That is, the cantilever beam style female socket contact can be stamped as a single part, while the simply supported beam style female contact must be stamped as two pieces. In a future edition, Technical Tidbits will compare and contrast the **one-piece** and **two-piece socket** designs and analyze the relevant tradeoffs.

Simply Supported Beam Springs (continued)

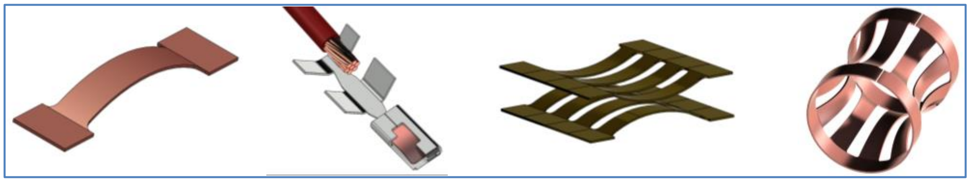


Figure 2. Electrical Contacts that are in the form of Simply Supported (Arch) Beams. The image at the far left shows a single arch beam. Next is a cutaway view of an automotive wire hardness terminal using an arch beam contact (the beam is shown without plating for clarity). The remaining images show the configuration of multiple contacts in typical connectors, with housing and wire terminations removed for clarity. The connectors on the third image would accept a male pin in the form of a flat blade, while that on the far right would accept a round male pin. One side would be restrained by the housing, while the other would be free to slide within the housing, and the beams would be free to pivot at both ends.

So, which type makes the most reliable spring? If you take the top equations in Figure 1 and solve for deflection as a function of stress, you can calculate the maximum deflection when the stress reaches the yield strength. By plugging this result into the force deflection equations, you can calculate the provided contact force at the yield strength. These results are tabulated below in Table 1.

	Deflection at Yield	Contact Force at Yield
Cantilever Beam	$\frac{2 \cdot L^2}{3 \cdot E \cdot t} \cdot \sigma_{yield}$	$\frac{w \cdot t^2}{6 \cdot L} \cdot \sigma_{yield}$
Arch Beam	$\frac{L^2}{6 \cdot E \cdot t} \cdot \sigma_{yield}$	$\frac{2 \cdot w \cdot t^2}{3 \cdot L} \cdot \sigma_{yield}$

Table 1. Comparison of Deflection and Contact Force at Yield between Beam Types.

Note that for the same dimensions, the cantilever beam allows for 4 times the deflection that the arch beam does, which provides much greater margin for accidental overdeflection of the contacts. On the other hand, the simply supported beam provides 4 times the contact force that the cantilever beam does. Each type has its own strength and weaknesses. If you are looking to maximize contact force for a given deflection, then the arch beam is for you. If you are looking to maximize permissible deflection, then a cantilever beam contact is in your future. Of course, these are only two of many spring types. Stay tuned to learn about some additional spring designs available to you.

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TECHNICAL TIDBITS

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©1978 Marcel-Dekker, Inc.

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