

# Optimizing Belleville Washer Stacks

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*Belleville washers*, also known as conical spring washers, are commonly used in mechanical assemblies to maintain preload and elasticity. These may be used as a machine element much like a coil spring. Bellevilles are also useful in bolted joints to compensate for relaxation and differential expansion. The flexibility of Belleville washers allows engineers to customize their load-deflection characteristics by varying stacking arrangements. This paper explores various stacks and how [Solon Manufacturing Company](#) can help to optimize the stack design based on performance and cost.

## Belleville Washer Basics

Belleville washers are characterized by their conical shape, which allows them to exert a predictable force when compressed. Key parameters influencing their behavior include:

- **Material Properties:** Based on environment and application.
- **Washer Thickness and Diameter:** Affects load and deflection.
- **Stacking Arrangement:** Dictates loading characteristics and overall displacement.

## Common Stacking Arrangements

### 1. Single Washer (Series of one)

- Provides given deflection and maximum force.
- Ideal for applications requiring high force with minimal displacement.

### 2. Series Stack (Spring constant reduction)

- Washers are stacked in alternating orientation.
- Increases overall deflection at a given maximum force.
- Used where greater displacement is required without excessive force increase.

### 3. Parallel Stack (Load amplification)

- Washers are stacked facing the same direction.
- Increases overall force output while keeping deflection relatively low.
- Suitable for applications requiring high preload and minimal displacement.

### 4. Combination of Series and Parallel Stacks

- Alternating series and parallel stacks allow fine-tuning of force and deflection characteristics.
- Provides a balance between load and deflection, offering flexibility in design.



**Single**  
Specific load and deflection



**Series**  
Doubles deflection - no load increase



**Parallel**  
Doubles load- no deflection increase



**Parallel/Series**  
Doubles load- doubles deflection



## What is the optimal stack design?

The optimal stack design would provide the required mechanical performance for the lowest possible cost. Solon is particularly well suited to providing an optimal solution for several reasons:

1. Many legacy springs stacks were designed using the German DIN standard washers. These tend to be relatively thin/light springs. As a result, stacks with high load requirements would need to employ multiple springs in parallel.
2. The OD/ID ratio for DIN washers tend to be small. This may be a requirement based on the OD constraints in a system. However, small changes in diameter can lead to substantial improvements in efficiency. The image below shows a DIN standard part next to a common Solon design.

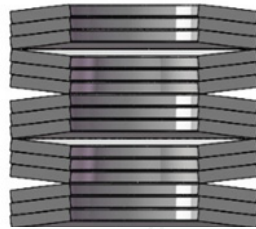


Standard DIN part



Solon® Belleville washer

3. Any time multiple springs are used in parallel, this means that more material would be required a given load vs deflection requirement. Since weight is closely related to cost, it is almost always advantageous to reduce the number of springs in parallel to the minimum. The figure below shows how a stack of fifteen springs could be reduced to only three.



Stack of standard DIN parts



Solon® Belleville stack

4. Springs in parallel increase the frictional [hysteresis](#) in the stack. This is typically not desirable in a spring system since friction energy is lost to heat.
5. Solon specializes in [high-load Bellevilles](#) where exacting tolerances are critical.

## Optimize your spring stack with Solon's engineering expertise

Achieve better performance, reduced costs, and enhanced efficiency with a tailored evaluation of your spring stack. Our engineers specialize in optimizing load distribution and selecting the best materials to maximize longevity and reliability in your application. By analyzing your specific requirements, we can identify areas for improvement that may result in fewer springs, lower overall costs, and improved system performance.

Let us help you enhance your design. [Contact Solon's engineering team](#) for a consultation and see how our expertise can make a difference in your application.

## ABOUT THE AUTHOR



George P. Davet, BSME, MBA is President, Chief Engineer and Owner at Solon Manufacturing Company and has written and published numerous articles on the use and application of Belleville spring washers. To learn more about Bellevilles and Solon Manufacturing, visit [www.solonmfg.com](http://www.solonmfg.com), for technical resources such as case studies, white papers, product selection tools and videos.



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