

Installation Techniques using Belleville Spring Washers

Based on NECA/AA 104-2012 Standards

Connecting Aluminum Conductors to Copper Terminal Lugs for Applications less than 2,000 Volts

3.4 Connecting Aluminum Conductors to Copper Terminal Lugs

3.4.1 Bolted Connection

A steel bolt should be used with a **Belleville spring washer** to allow for the differing rates of thermal expansion of the materials.

a) Use the components furnished or specified by the equipment manufacturer.

These may include:

- **Steel Bolts** - Plated or galvanized, medium carbon steel, heat treated, SAE grade 5.
- **Nuts** - Heavy semi finished hexagonal, conforming to ANSI B18.2.2 coarse threads, class 2B.
- **Flat Washers** - Steel, Type A, plain standard wide series per ANSI B27.2. (do not use SAE or narrow series)
- **Belleville Spring Washer** - 6150 Alloy Steel (or equivalent) heat treated, mechanical zinc plated.

The **Belleville spring washer** should be installed between the flat washer and the nut. *(Recommended sizes are shown in chart below.)*

All hardware should be lubricated with silicon spray or other suitable lubricant when tightening.

b) When using **Belleville spring washers**, bolts should be tightened until a sudden increase in torque is felt. This indicates the Belleville spring is flattened and no torque wrench is required.

Recommended Belleville Spring Washer Sizes per the NECA/AA 104-2012 Standard

Bolt Diameter (Inch size)	OD	THK	Solon Belleville Spring Washer
1/4	0.688	0.053	4M52
5/16	0.813	0.062	5M61
3/8	0.938	0.072	6M70
7/16	1.063	0.082	7M80
1/2	1.188	0.091	8M89
5/8	1.500	0.115	10M112

4M52

5M61

6M70

7M80

8M89

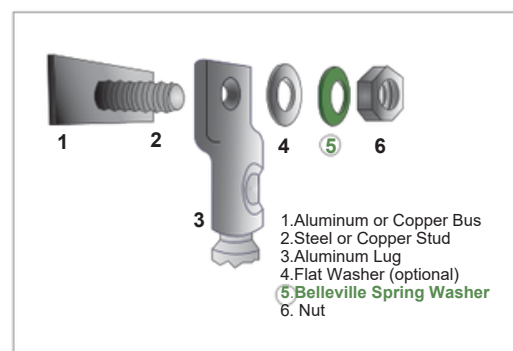
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Notes:

Material: Alloy Steel or High Carbon Steel, DFAR Compliant

Finish: Mechanical Zinc Plated, ROHS Compliant

Finished Product: USA Manufactured



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Every electrical connection is vital because there is potential for a catastrophic failure.

Belleville springs, also called Belleville washers, are conical shaped discs that will flatten at a given spring rate. Belleville's are used on electrical connections when the components of the connection are made of dissimilar (AL7CU or AL9CU) and similar materials because they maintain the bolt preload.



Benefits of Belleville Spring Washers

One benefit of Belleville spring washers includes compensating the effects of **thermal cycling** by maintaining sufficient bolt load; therefore, reducing hot spots. Heat is produced on electrical connections from the electrical resistance between the conductive material and the bolt. Hot spots occur with the increase of resistance due to the loosening of the joint. The result of a hot spot can be a catastrophic failure.

Another condition that Belleville's compensate for is **creep**. Properly used Belleville's maintain the desired load, despite any conductor creep and, again, reduce the opportunity for a failure.

Electrical connections may loosen because of embedment relaxation, which over time causes microscopic high points on both the threads and mating surfaces of the connection to relax. Belleville springs counteract the effects of embedment relaxation.

Vibration is another factor that can loosen bolted electrical connections that don't include Belleville spring washers. The Belleville acts as a shock absorber by maintaining a constant sufficient load on the connection.

**Thermal cycling, creep, and embedment relaxation are no match for Belleville springs.
Quality Belleville springs will keep bolted connections tight!**

Belleville Spring FAQ's

- Q. Will I always use the same size Belleville spring on the same size bolt?
- A. **Not always. Some manufacturers and utilities specify different size Belleville springs for their particular applications. It's important to use installation procedures stated by the manufacturer, utility, or state and local code first.**
- Q. Can I install the Belleville spring incorrectly?
- A. **Yes, the Belleville spring must be installed with the convex, or top side, towards the nut. If it is installed upside down, you will not be able to compress the Belleville spring completely and will not get the full benefit of using the Belleville spring.**
- Q. Can I use a torque wrench if I am using Belleville springs?
- A. **Absolutely. Although it is not required, anytime you can improve the accuracy of the torque measurement, the better the installation and its reliability.**
- Q. Would I ever use a Belleville spring other than one made from Alloy steel?
- A. **Yes, although Alloy steel is the recommended material specified in the NECA spec, many manufacturers and utilities have specified using 301 Stainless Steel or 17-7 PH Stainless Steel, and 510 Phosphor Bronze and occasionally Inconel 718 or X-750.**
- Q. Can Belleville springs be re-used?
- A. **Yes, as long as they have not been exposed to a temperature higher than that they are rated for, or have not been exposed to an environment that could cause the springs to crack. Contacting the manufacturer is best if you have any concerns.**
- Q. Can I damage the Belleville spring by over-tightening?
- A. **Generally, no. You are more likely to damage the bolt, and/or the mating contact surfaces. It is never a good idea to over-tighten a bolt.**



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