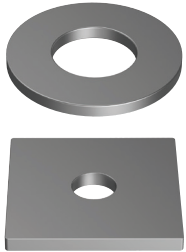




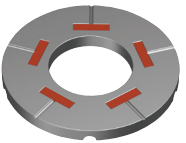
## Types of Washers



### Standard Washers

A standard washer is a thin plate, typically round or square, with a hole that is normally in the centre. They are used for two main reasons:

1. To minimise scouring or scratch damage to mating material as a result of nut rotation.
2. To increase the effective bearing surface of the bolt and/or nut. That is, to distribute the load of a threaded fastener over a larger area and prevent deformation of the bearing surfaces.



### Squirter Washers (DTIs)

Direct tension indicating (DTI) washers are used to ensure the required pre-load tension in a joint is achieved. They are hardened washers with protruding bumps on the bearing face. When the bolt assembly is tightened, these bumps are deformed to a prescribed level and indicate that the required tension has been achieved. During the deformation process, silicone is squeezed out, giving a visible sign of correct tension in the bolt assembly.



### Load Indicating Washers (LIWs)

Work similarly to Squirter Washers (DTIs) minus the silicone process.



### Split Type

Developed 110 years ago, the split-type spring washer was the first washer to offer a solution to the loosening of bolted assemblies. These are hardened washers that are split with out-of-plane deformations. They should be used under the head of the bolt while the assembly is tensioned by rotating the nut. If they need to be used on the nut side, another hardened flat round washer should be used between the nut and the split washer.

When the washers are flattened, the prescribed tension is achieved in the assembly. Naturally, these washers do not indicate any over-tightening of the bolt assembly. The split-lock washers are made from hardened spring steel that strongly resists compression. When the threaded fasteners are tightened, the protruding corner edges of the split-lock washers bite into both compressing surfaces in a manner that resists counter-clockwise rotation, similar to a ratchet.



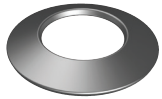
### Spring Washers

"Threaded assemblies inherently involve the mating of inclined planes under load. These inclined planes consist of the lead and flank angle of the screw or bolt thread and the angle of the mating thread in the nut plate. There is a natural tendency for these mating threads to slide 'downhill' until tension is lost in an assembly. If assembled materials are soft or yield under load, or if thermocycling causes expansion and contraction of the materials, essential tension dissipates fairly quickly".<sup>1</sup> There are various types of spring washers that are designed to prevent loosening of bolted assemblies.

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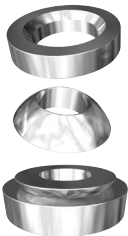
## Types of Washers



### Belleville Washer

A Belleville washer, also known as a coned disc spring or conical washer and cupped spring washer, is a type of spring shaped like a washer. It has a frustoconical shape which gives it a spring characteristic and is named after the inventor Julian F. Belleville. In the initial tightening, the effect on the joint is similar to a split-type spring washer. However, as the tightening continues and the washer is flattened, it reduces the applied load in the bolt assembly. In this way, if the joint is loosened, the load will increase and counteract the loosening of the joint.

Multiple Belleville washers may be stacked to modify the spring constant or amount of deflection.



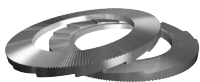
### Spherical Washer

Spherical washers are designed to accommodate a 10–15 degree variation in the alignment of a joint. A cone washer fits inside a cup washer and they slide against each other to reduce bending stresses in the bolt. One application for these washers is in racing kart seats where the chassis twists dramatically.



### Lock Washer

A toothed lock washer, also known as a star washer, has teeth or prongs that extend radially inward and/or outward. The flexed teeth absorb shock, vibrations, and slipping, which maintains tension and opposes any loosening influence on the fastener. These washers are designed to retain fasteners by achieving an increased friction between the fastener and the mating material through mechanical interlocking or interference. They also provide some tension, as with spring washers, but at a vastly reduced magnitude. There are two main types: teeth twisted out of plane (Type A) and edges of the teeth folded in opposite directions (Type B).



### Lock Washer — Two-Piece Type (Nord-Lock)

Two-piece lock washers are designed to prevent bolt assemblies loosening due to vibration and consist of two discs with interposing ramps. "Sharp ridges on the upper and lower surfaces of the discs grab the nut and joint surfaces. If the nut backs off a little it drags its disc along with it; the ramps on its disc climb the ramps on the lower disc. The interaction of these ramp or cam surfaces prevent loss of tension in the bolt".<sup>2</sup>



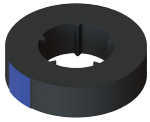
### Nylon Washer

Natural or Black (UV stable) polyamide washers are primarily used as a barrier between dissimilar metals, for electrical insulation purposes between conductive parts, to protect a bearing surface, and to absorb shocks and vibrations.

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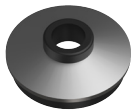


## Types of Washers



### Sealing Washer

UV-resistant sealing washers are designed to create a waterproof seal when fixing roof sheets or cladding with timber for metal self-drilling screws.



### Cyclone Washer

25 mm OD multi-seal, aluminium/EPDM bonded washers are for use with 14g screws in crest fixing of metal roofing to timber or steel battens and purlins in high-wind (cyclonic) conditions.



#### References:

Ajax technical note AF1/02/007

<sup>1</sup> Jacobs, C. F. (1997). *American Fastener Journal*.

<sup>2</sup> Bickford, J. H. (1981). *An Introduction to the Design and Behavior of Bolted Joints*. CRC Press.

Smith, C. (1990). *Nuts, Bolts, Fasteners and Plumbing Handbook*. Motorbooks.

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