



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 lugs or bumps on the bearing face. When the bolt assembly is tightened, these lugs are deformed to a prescribed level and hence indicate that the required tension in the assembly has been achieved. During the lug deformation process, silicone is squeezed out, giving a visible sign of correct tension in the bolt assembly.



Load Indicating Washers (LIWs)

Work much the same as Squirter Washers (DTIs) minus the silicone process.



Split type

Developed 110 years ago, the split type spring washer was the first washer that offered 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 with the assembly being 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, a 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 to vibration in a manner 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”¹. There are various types of spring washers that are designed to prevent loosening of bolted assemblies.

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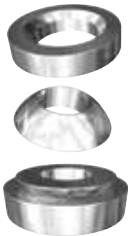
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Belleville Washer

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 frusto-conical shape which gives the washer a spring characteristic. The Belleville name comes from the inventor Jullian 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 actually reduces the applied load in the bolt assembly. In this way, if the joint is loosened, the load will increase and hence counteract the loosening of the joint.

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



Spherical Washers

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 Washers

A toothed lock washer, also known as a star washer, has teeth or prongs which extend radially inward and/or outward. This maintains tension and opposes any loosening influence on the fastener. The flexed teeth absorb shock, vibration and slipping. 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 Washers – 2 piece type (Nord-Lock)

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

References:

Ajax technical note AF1/02/007

¹ Charles F Jacobs. American Fastener Journal 1997

² An Introduction to the design and behaviour of bolted joints. John H Bickford

Nuts, Bolts, Fasteners and Plumbing Handbook. Carroll Smith

Wikipedia

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