

Comprehensive Guide to Self-Locking Nuts

In the field of fasteners, nuts serve as core components paired with bolts, playing a crucial role in securing connections and transmitting loads. As a specialized category within the nut family, self-locking nuts offer the dual advantages of "tightening" and "anti-loosening." Because they do not require additional anti-loosening devices and are adaptable to complex working conditions, they are widely used in various fields such as machinery, construction, and new energy. While many industry professionals understand that self-locking nuts prevent loosening, they may not fully grasp the underlying working principles, structural differences, or specific application scenarios. This article provides a comprehensive breakdown of self-locking nuts, highlighting their unique features to offer practical guidance for fastener selection and application.

First, let us clarify the core definition: As the name suggests, a self-locking nut is a specialized nut that maintains connection tightness and prevents loosening under complex conditions like vibration, impact, and load changes, relying solely on its own structural design without the need for external anti-loosening components (such as spring washers or cotter pins). Compared to standard nuts, the core advantage of self-locking nuts lies in their self-locking anti-loosening capability. Essentially, through structural optimization, they increase the friction between threads or utilize mechanical locking mechanisms to counteract the loosening tendency caused by vibration, thereby ensuring connection stability and safety.

To understand the working principle of self-locking nuts, one must first identify the primary cause of standard nut loosening: Standard metric threads have a lead angle greater than the friction angle between threads. When subjected to vibration or impact, the friction between the bolt and nut decreases, causing relative sliding between threads and eventual loosening. Self-locking nuts address this by altering the thread structure, increasing frictional resistance, or incorporating locking mechanisms to ensure the lead angle is less than or equal to the friction angle, or by mechanically restricting relative thread sliding to achieve the self-locking effect.

Based on structural design, the working principles of self-locking nuts are mainly divided into two categories: Friction-based self-locking, which increases friction between threads and between the nut and connected parts to counteract loosening (common in nylon lock nuts and metal lock nuts); and Mechanical structure-based self-locking, which utilizes locking or engagement mechanisms to directly restrict the relative rotation between the bolt and nut (common in

slotted nuts and clinch nuts). Different principles dictate varying application scenarios and anti-loosening effectiveness.

Next, we will detail the most commonly used self-locking nut types in the industrial sector, breaking down their structural features, working principles, and application scenarios to aid in precise selection.

The first type is the Nylon Lock Nut (also known as a nylon insert lock nut), which is currently the most widely used self-locking nut. Structurally, a high-temperature and wear-resistant nylon ring is embedded at one end of the nut. The inner diameter of the nylon ring is slightly smaller than the outer diameter of the bolt. When the bolt is threaded into the nut, the nylon ring expands and tightly wraps around the bolt threads. Utilizing the high friction between nylon and metal, along with the elastic deformation of the nylon ring, it increases thread resistance to achieve self-locking.

The advantages of nylon lock nuts are significant: simple structure, low cost, easy installation without additional anti-loosening devices, and a certain degree of buffering and shock absorption, making them suitable for light vibration conditions. Additionally, nylon offers good electrical insulation, making it ideal for electrical and electronic equipment. However, it has limitations: the nylon ring has limited high-temperature resistance, typically operating between -40°C and 120°C . Beyond this range, the nylon softens and ages, losing its anti-loosening effect. Furthermore, as the nylon ring is a consumable that wears out after multiple disassemblies, it is best suited for connections that are rarely dismantled, such as home appliances, automotive components, and photovoltaic equipment brackets.

The second type is the Metal Lock Nut, which offers superior high-temperature and wear resistance compared to nylon variants, making it suitable for harsh conditions involving high temperatures, high pressure, and severe vibrations. There are two common types: All-metal lock nuts, which feature elastic grooves machined into the threads; when the bolt is threaded in, the grooves deform, exerting continuous pressure to increase friction. Metal insert lock nuts, which incorporate metal elastic clips or washers that rely on metal elastic deformation for a more stable locking force.

Metal lock nuts have a broad range of applications, especially in high-temperature environments like engines, boilers, and chemical equipment, with temperature resistance exceeding 200°C . They also allow for more disassembly cycles and a longer service life than nylon lock nuts. However, they are relatively more expensive, and installation requires precise torque control to prevent damage to the elastic grooves or metal inserts, which could compromise the anti-loosening effect.

The third type is the Slotted Nut (or Castle Nut), a typical representative of mechanical structure self-locking. It features 2-4 evenly distributed slots at one end and is used in conjunction with a cotter pin. After the bolt is threaded and tightened, the cotter pin is inserted through the slot in the nut and the hole at the end of the bolt. Bending both ends of the cotter pin restricts relative rotation between the nut and bolt, achieving anti-loosening.

The advantage of slotted nuts is their highly reliable anti-loosening performance, capable of withstanding severe vibration and impact. They are ideal for safety-critical applications such as aerospace, marine, and heavy machinery. However, installation and disassembly are relatively cumbersome, requiring a cotter pin which is a single-use consumable that must be replaced after disassembly. Thus, they are best suited for critical, long-term fixed connections that are rarely dismantled.

Beyond these three mainstream types, there are specialized self-locking nuts such as clinch nuts, press-in nuts, and weld nuts. These permanently integrate the nut with the connected part through riveting, pressing, or welding, further enhancing connection stability. They are ideal for thin-walled parts or sheet metals where traditional tightening methods cannot be applied, such as automotive bodies and electronic equipment enclosures.

Having explored the types and principles, let us discuss the core characteristics that distinguish self-locking nuts from standard nuts. First is the self-locking anti-loosening property, which maintains tightness under complex conditions without extra parts, effectively preventing equipment failures or safety accidents. Second is strong adaptability; different types can accommodate high/low temperatures, vibrations, and insulation requirements across various industries. Third is installation convenience; most can be tightened with standard wrenches without specialized tools, improving efficiency. Finally is economic efficiency; compared to the combination of "standard nuts + anti-loosening parts," most self-locking nuts are more cost-effective and reduce installation steps, lowering overall construction costs.

In practical applications, selecting the right self-locking nut is critical. Improper selection can lead to connection failure. Three core factors must be considered: Operating conditions (temperature, vibration intensity, corrosive environment); for instance, metal lock nuts are preferred for high temperatures, while nylon lock nuts are chosen for insulation needs. Disassembly frequency; nylon lock nuts suit infrequent disassembly, whereas metal lock nuts are better for frequent dismantling. Load requirements; heavy-load and high-impact scenarios demand metal lock nuts or slotted nuts, while light-load, low-vibration scenarios can use cost-effective nylon lock nuts.

Additionally, certain precautions are necessary to ensure anti-loosening effectiveness. First, tightening torque must be moderate; excessive torque can damage the locking structure (e.g., nylon ring, elastic grooves), while insufficient torque fails to guarantee locking force. Second, avoid using them beyond their specified temperature or corrosion limits to prevent accelerated aging. Third, after multiple disassemblies, inspect the locking structure for wear or deformation, and replace the nut if necessary. Fourth, ensure the bolt and nut threads match perfectly during installation to prevent thread stripping.

For fastener enterprises, self-locking nuts represent high-value-added specialty products, and their R&D and production capabilities directly reflect technical strength. As downstream industries (such as new energy, aerospace, and high-end equipment) upgrade, the demands for self-locking nuts continue to rise. They must not only offer reliable anti-loosening performance but also meet requirements for lightweight design, high precision, and corrosion resistance. Therefore, enterprises need to increase R&D investment, optimize product structures, and enhance product quality to introduce self-locking nuts tailored for various high-end scenarios. Simultaneously, strengthening educational outreach helps industry professionals correctly understand and rationally select these products, thereby boosting market competitiveness.